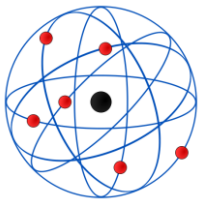


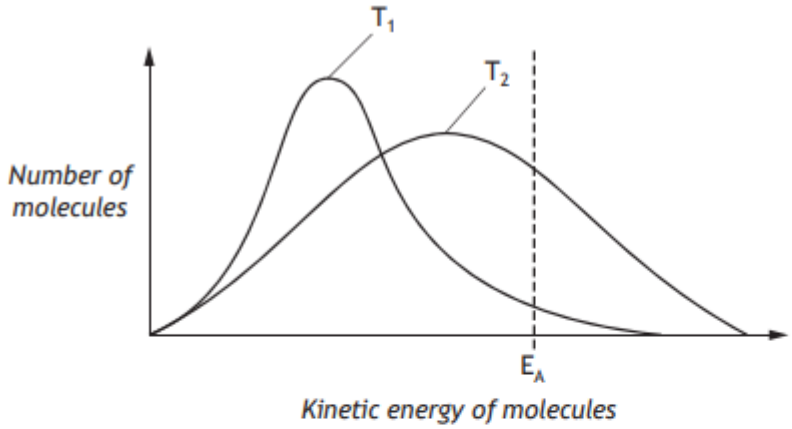
Higher Chemistry

Unit 3 Past Paper Questions

Unit 3– Chemistry in Society

SECTION 1

1



Which of the following is the correct interpretation of the above energy distribution diagram for a reaction as the temperature **decreases** from T_2 to T_1?

	Activation energy (E_A)	*Number of successful collisions*
A	remains the same	increases
B	decreases	decreases
C	decreases	increases
D	remains the same	decreases

2.

$Cl_2(g) + H_2O(\ell) \rightleftharpoons Cl^-(aq) + ClO^-(aq) + 2H^+(aq)$

The addition of which of the following substances would move the above equilibrium to the right?

A Hydrogen

B Hydrogen chloride

C Sodium chloride

D Sodium hydroxide

3.

$$ICl(\ell) + Cl_2(g) \rightleftharpoons ICl_3(s) \qquad \Delta H = -106 kJ\,mol^{-1}$$

Which line in the table identifies correctly the changes that will cause the greatest increase in the proportion of solid in the above equilibrium mixture?

	Temperature	*Pressure*
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

4.

Chemical reactions are in a state of dynamic equilibrium only when

A the reaction involves no enthalpy change

B the concentrations of reactants and products are equal

C the activation energies of the forward and backward reactions are equal

D the rate of the forward reaction equals that of the backward reaction.

5.

Which line in the table best describes the effect of adding a catalyst to the following reaction?

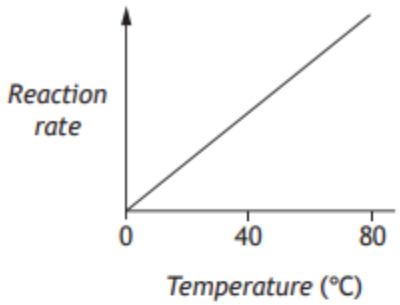
$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H = -ve$$

	Position of equilibrium	*Rate of forward reaction*
A	unchanged	unchanged
B	unchanged	increased
C	moves to right	unchanged
D	moves to right	increased

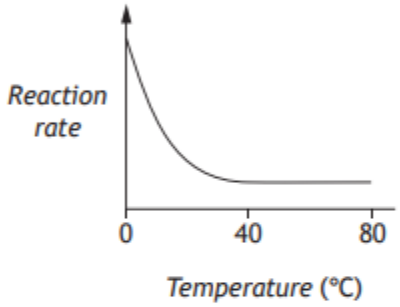
6.

The rate of hydrolysis of protein, using an enzyme, was studied at different temperatures.
Which of the following graphs would be obtained?

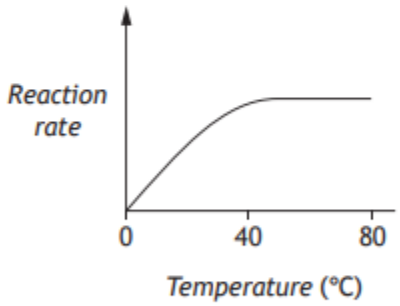
A



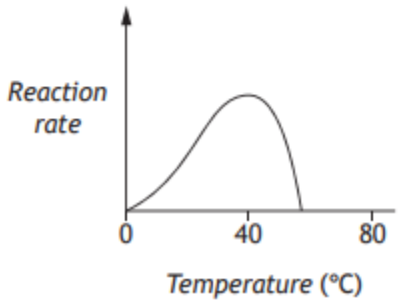
B



C



D



7. In a reversible reaction, equilibrium is reached when

A molecules of reactants cease to change into molecules of products

B the concentrations of reactants and products are equal

C the concentrations of reactants and products are constant

D the activation energy of the forward reaction is equal to that of the reverse reaction.

8. Which of the following equations represents the enthalpy of combustion of propane?

A $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell)$

B $C_3H_8(g) + \frac{7}{2}O_2(g) \rightarrow 3CO(g) + 4H_2O(\ell)$

C $C_3H_8(g) + 3O_2(g) \rightarrow 3CO_2(g) + 4H_2(g)$

D $C_3H_8(g) + \frac{3}{2}O_2(g) \rightarrow 3CO(g) + 4H_2(g)$

9. Which of the following statements regarding a chemical reaction at equilibrium is always correct?

A The rates of the forward and reverse reactions are equal.

B The concentration of reactants and products are equal.

C The forward and reverse reactions have stopped.

D The addition of a catalyst changes the position of the equilibrium.

10. Which of the following is the best description of a feedstock?

A A consumer product such as a textile, plastic or detergent.

B A complex chemical that has been synthesised from small molecules.

C A mixture of chemicals formed by the cracking of the naphtha fraction from oil.

D A chemical from which other chemicals can be extracted or synthesised.

11. Ethanol is manufactured by reacting ethene with steam.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -46\ \text{kJ mol}^{-1}$$

Which set of conditions would give the best yield of ethanol at equilibrium?

A High temperature, low pressure

B High temperature, high pressure

C Low temperature, high pressure

D Low temperature, low pressure

12.

In which reaction is the volume of products less than the volume of reactants?

A $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

B $2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$

C $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

D $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$

13.

Hydrogen and chlorine react to form hydrogen chloride.

$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

Bond	Bond enthalpy/kJ mol^{-1}
H−H	432
Cl−Cl	243
H−Cl	428

What is the enthalpy change, in kJ mol^{-1}, for the above reaction?

A +181

B −181

C +247

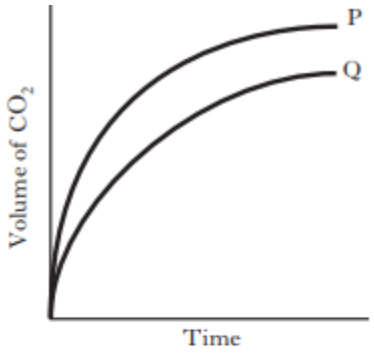
D −247

14.

Which line in the table shows the effect of a catalyst on the reaction rates and position of equilibrium in a reversible reaction?

	Rate of forward reaction	Rate of reverse reaction	Position of equilibrium
A	increased	unchanged	moves right
B	increased	increased	unchanged
C	increased	decreased	moves right
D	unchanged	unchanged	unchanged

15.



When copper carbonate is reacted with excess acid, carbon dioxide is produced. The curves shown above were obtained under different conditions.

The change from P to Q could be brought about by

A increasing the concentration of the acid

B decreasing the mass of copper carbonate

C decreasing the particle size of the copper carbonate

D adding a catalyst.

16.

Which of the following is **not** a correct statement about the effect of a catalyst?

The catalyst

A provides energy so that more molecules have successful collisions

B lowers the energy which molecules need for successful collisions

C provides an alternative route to the products

D forms bonds with reacting molecules.

17.

Which of the following equations represents an enthalpy of combustion?

A $C_2H_6(g) + 3\frac{1}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(\ell)$

B $C_2H_5OH(\ell) + O_2(g) \rightarrow CH_3COOH(\ell) + H_2O(\ell)$

C $CH_3CHO(\ell) + \frac{1}{2}O_2(g) \rightarrow CH_3COOH(\ell)$

D $CH_4(g) + 1\frac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(\ell)$

18.

The mean bond enthalpy of the N−H bond is equal to one third of the value of ΔH for which change?

A $N(g) + 3H(g) \rightarrow NH_3(g)$

B $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

C $\frac{1}{2}N_2(g) + 1\frac{1}{2}H_2(g) \rightarrow NH_3(g)$

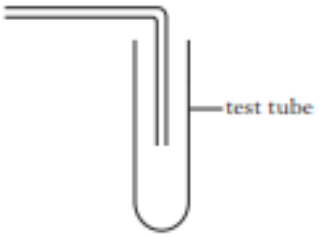
D $NH_3(g) \rightarrow \frac{1}{2}N_2(g) + 1\frac{1}{2}H_2(g)$

19.

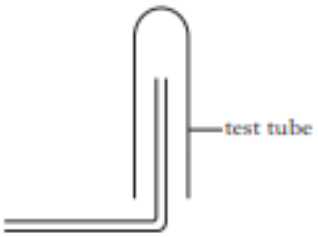
Sulphur dioxide gas is more dense than air and is very soluble in water.

Which of the following diagrams shows the most appropriate apparatus for collecting and measuring the volume of sulphur dioxide given off in a reaction?

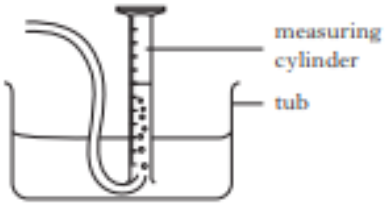
A



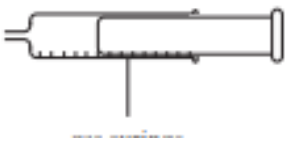
B



C



D



20.

A few drops of concentrated sulphuric acid were added to a mixture of 0·1 mol of methanol and 0·2 mol of ethanoic acid. Even after a considerable time, the reaction mixture was found to contain some of each reactant.

Which of the following is the best explanation for the incomplete reaction?

A The temperature was too low.

B An equilibrium mixture was formed.

C Insufficient methanol was used.

D Insufficient ethanoic acid was used.

21. Which line in the table applies correctly to the use of a catalyst in a chemical reaction?

	Position of equilibrium	**Effect on value of ΔH**
A	Moved to right	Decreased
B	Unaffected	Increased
C	Moved to left	Unaffected
D	Unaffected	Unaffected

22.

In a reaction involving gases, an increase in temperature results in

A an increase in activation energy

B an increase in the enthalpy change

C a decrease in the activation energy

D more molecules per second forming an activated complex.

23.

In the presence of bright light, hydrogen and chlorine react explosively. One step in the reaction is shown below.

$H_2(g) + Cl(g) \rightarrow HCl(g) + H(g)$

The enthalpy change for this step can be represented as

A (H-H bond enthalpy) + (Cl-Cl bond enthalpy)

B (H-H bond enthalpy) − (Cl-Cl bond enthalpy)

C (H-H bond enthalpy) + (H-Cl bond enthalpy)

D (H-H bond enthalpy) − (H-Cl bond enthalpy).

24.

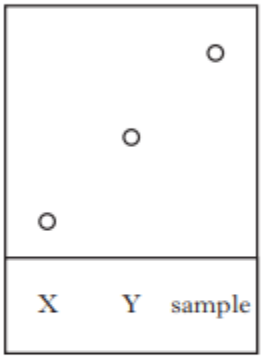
An organic chemist is attempting to synthesise a fragrance compound by the following chemical reaction.

compound **X** + compound **Y** → fragrance compound

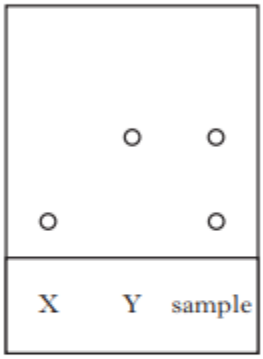
After one hour, a sample is removed and compared with pure samples of compounds **X** and **Y** using thin-layer chromatography.

Which of the following chromatograms shows that the reaction has produced a pure sample of the fragrance compound?

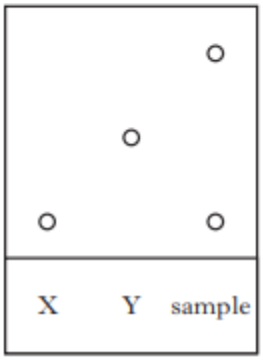
A



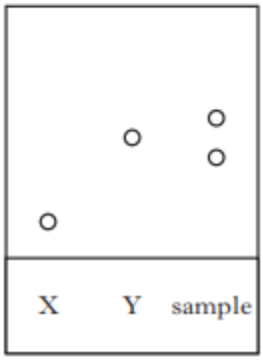
B



C



D



25.

In which of the following will both changes result in an increase in the rate of a chemical reaction?

A A decrease in activation energy and an increase in the frequency of collisions

B An increase in activation energy and a decrease in particle size

C An increase in temperature and an increase in the particle size

D An increase in concentration and a decrease in the surface area of the reactant particles

26.

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

The equation represents a mixture at equilibrium.

Which line in the table is true for the mixture after a further 2 hours of reaction?

	Rate of forward reaction	**Rate of back reaction**
A	decreases	decreases
B	increases	increases
C	unchanged	decreases
D	unchanged	unchanged

27.

In which of the following would an increase in pressure result in the equilibrium position being moved to the left?

A $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

B $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

C $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$

D $Fe_2O_3(s) + 3CO(g) \rightleftharpoons 2Fe(s) + 3CO_2(g)$

28.

Ammonia is made by the Haber Process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The equilibrium position lies to the left.

Which line in the table is correct?

	Atom Economy	**Percentage Yield**
A	high	high
B	high	low
C	low	high
D	low	low

29.

Which line in the table describes dynamic equilibrium?

	Concentration of reactants and products	**Forward and reverse reaction rates**
A	constant	equal
B	constant	not equal
C	not constant	equal
D	not constant	not equal

30. Aluminium carbonate can be produced by the following reaction.

$$2AlCl_3(aq) + 3K_2CO_3(aq) \rightarrow Al_2(CO_3)_3(s) + 6KCl(aq)$$

The most suitable method for obtaining a sample of the aluminium carbonate is

A collection over water

B distillation

C evaporation

D filtration.

31.

The following reaction takes place in a blast furnace:

$CO_2(g) + C(s) \rightleftharpoons 2CO(g) \quad \Delta H = +174\,kJ\ mol^{-1}$

Which conditions of pressure and temperature would favour the production of carbon monoxide?

A Low pressure and low temperature

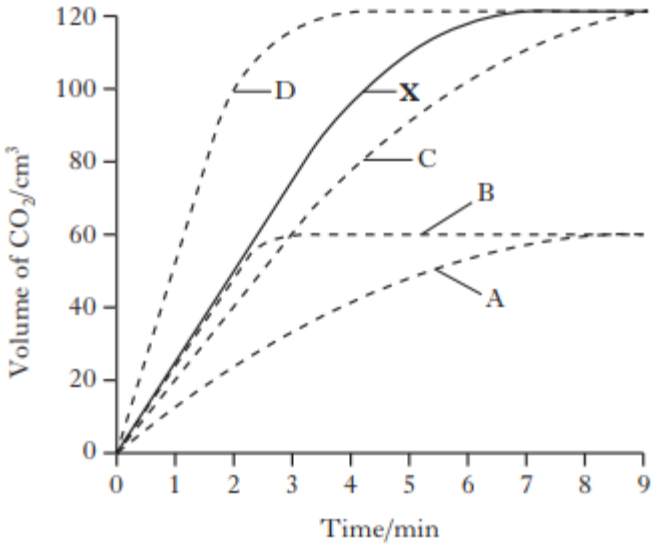
B High pressure and low temperature

C Low pressure and high temperature

D High pressure and high temperature

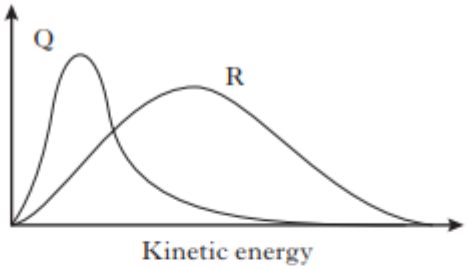
32

22. Graph **X** was obtained when 1 g of calcium carbonate powder reacted with excess dilute hydrochloric acid at 20 °C.



Which curve would best represent the reaction of 0·5 g lump calcium carbonate with excess of the same dilute hydrochloric acid?

33. **23.**



Which line in the table is correct for curves **Q** and **R** in the above graph?

	Curve Q	**Curve R**
A	1 mol of O_2 at 50 °C	2 mol of O_2 at 100 °C
B	1 mol of O_2 at 100 °C	2 mol of O_2 at 100 °C
C	2 mol of O_2 at 50 °C	1 mol of O_2 at 100 °C
D	2 mol of O_2 at 100 °C	1 mol of O_2 at 100 °C

34.

The enthalpy of combustion of an alcohol is always the enthalpy change for

A the alcohol burning in 1 mole of oxygen

B the alcohol burning to produce 1 mole of water

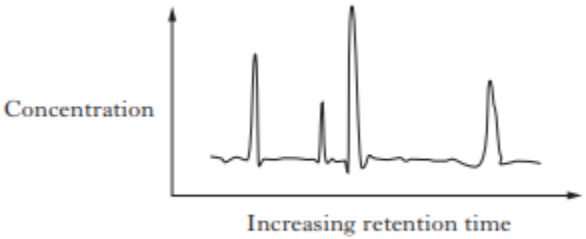
C 1 mole of the alcohol burning completely in oxygen

D 1 mole of the alcohol burning to produce 1 mole of carbon dioxide.

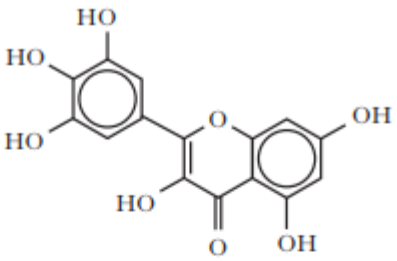
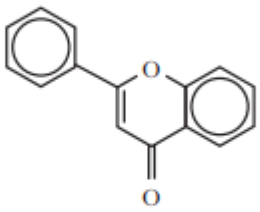
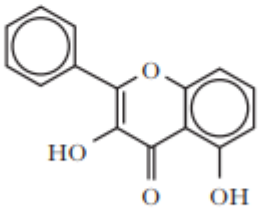
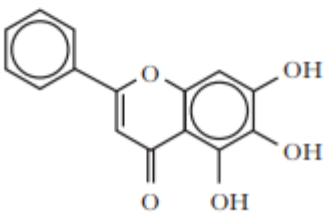
35.

28. A chemist analysed a mixture of four dyes A, B, C and D using gas-liquid chromatography.

When a polar column was used the following chromatogram was obtained.



Which of the following compounds was present in greatest concentration?

Dye	Structure
A	
B	
C	
D	

36.

The correct method of filling a 20 cm^3 pipette is to draw the liquid into the pipette

A doing it slowly at the end, until the top of the meniscus touches the mark

B doing it slowly at the end, until the bottom of the meniscus touches the mark

C to above the mark and then release liquid from the pipette until the top of the meniscus touches the mark

D to above the mark and then release liquid from the pipette until the bottom of the meniscus touches the mark.

37.

A 0·10 mol l^{-1} solution could be prepared most accurately from a 1·0 mol l^{-1} solution using

A a 1 cm^3 dropping pipette and a 10 cm^3 measuring cylinder

B a 10 cm^3 measuring cylinder and a 100 cm^3 volumetric flask

C a 25 cm^3 pipette and a 250 cm^3 volumetric flask

D a 50 cm^3 burette and a 500 cm^3 measuring cylinder.

38.

Which of the following statements regarding a chemical reaction at equilibrium is always true?

A The rates of the forward and reverse reactions are equal.

B The concentration of reactants and products are equal.

C The forward and reverse reactions have stopped.

D The addition of a catalyst changes the position of equilibrium.

39.

In which of the following systems will the equilibrium be **unaffected** by a change in pressure?

A $2NO_2(g) \rightleftharpoons N_2O_4(g)$

B $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

C $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$

D $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

40.

25. The following equilibrium exists in bromine water.

$$\underset{\text{(red)}}{Br_2(aq)} + H_2O(\ell) \rightleftharpoons \underset{\text{(colourless)}}{Br^-(aq)} + 2H^+(aq) + \underset{\text{(colourless)}}{OBr^-(aq)}$$

The red colour of bromine water would fade on adding a few drops of a concentrated solution of

A HCl

B KBr

C $AgNO_3$

D $NaOBr$.

41.

In which of the following reactions would the products have a lower volume than the reactants?

A $2C(s) + O_2(g) \rightarrow 2CO(g)$

B $C(s) + O_2(g) \rightarrow CO_2(g)$

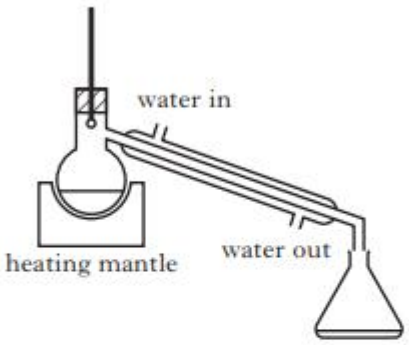
C $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(\ell)$

D $Ca(OH)_2(aq) + 2CO_2(g) \rightarrow Ca(HCO_3)_2(aq)$

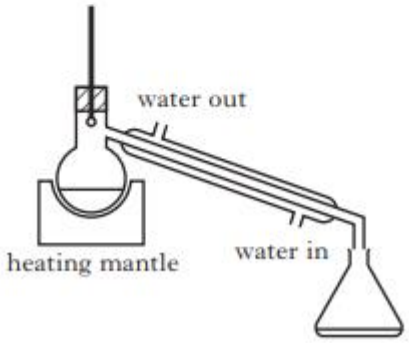
42.

Which of the following diagrams shows the correct set up for the separation of ethanol from ethanoic acid?

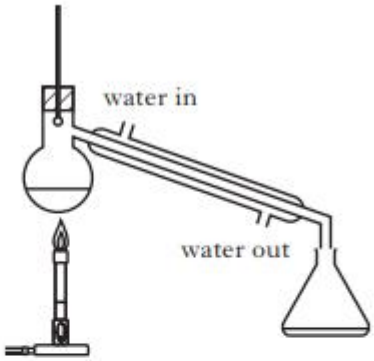
A



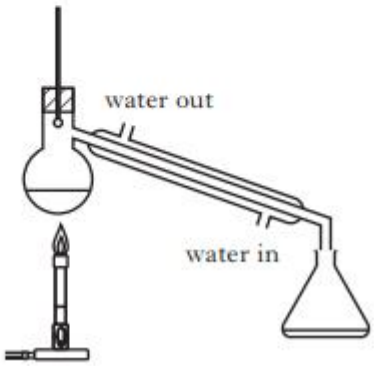
B



C



D



43.

Which of the following would **not** help a student determine the end point of a titration accurately?

A Swirling the flask.

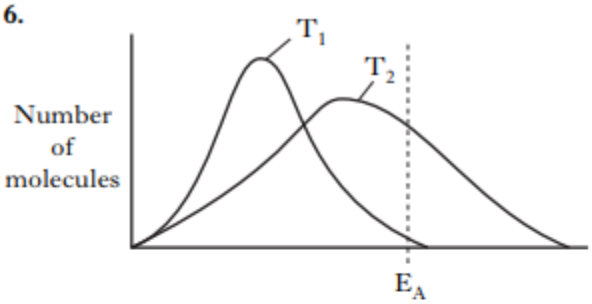
B Using a white tile.

C Adding the solution dropwise near the end-point.

D Repeating the titration.

44.

6.



Kinetic energy of molecules

Which line in the table is correct for a reaction as the temperature **decreases** from T_2 to T_1?

	Activation energy (E_A)	**Number of successful collisions**
A	remains the same	increases
B	decreases	decreases
C	decreases	increases
D	remains the same	decreases

45.

For any chemical, its temperature is a measure of

A the average kinetic energy of the particles that react

B the average kinetic energy of all the particles

C the activation energy

D the minimum kinetic energy required before reaction occurs.

46.

Which of the following is **not** a correct statement about the effect of a catalyst?

The catalyst

A provides an alternative route to the products

B lowers the energy that molecules need for successful collisions

C provides energy so that more molecules have successful collisions

D forms bonds with reacting molecules.

47.

A potential energy diagram can be used to show the activation energy (E_A) and the enthalpy change (ΔH) for a reaction.

Which of the following combinations of E_A and ΔH could **never** be obtained for a reaction?

A $E_A = 50\,kJ\ mol^{-1}$ and $\Delta H = -100\,kJ\ mol^{-1}$

B $E_A = 50\,kJ\ mol^{-1}$ and $\Delta H = +100\,kJ\ mol^{-1}$

C $E_A = 100\,kJ\ mol^{-1}$ and $\Delta H = +50\,kJ\ mol^{-1}$

D $E_A = 100\,kJ\ mol^{-1}$ and $\Delta H = -50\,kJ\ mol^{-1}$

48.

In which of the following reactions would an increase in pressure cause the equilibrium position to move to the left?

A $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

B $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$

C $Fe_2O_3(s) + 3CO(g) \rightleftharpoons 2Fe(s) + 3CO_2(g)$

D $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

49.

30. The following equilibrium exists in bromine water.

$$\underset{\text{(red)}}{Br_2(aq)} + H_2O(\ell) \rightleftharpoons \underset{\text{(colourless)}}{Br^-(aq)} + 2H^+(aq) + \underset{\text{(colourless)}}{OBr^-(aq)}$$

The red colour of bromine water would fade on adding a few drops of a concentrated solution of

A HCl

B KBr

C $AgNO_3$

D NaOBr.

50.

Steam and carbon monoxide react to form an equilibrium mixture.

$$CO(g) + H_2O(g) \rightleftharpoons H_2(g) + CO_2(g)$$

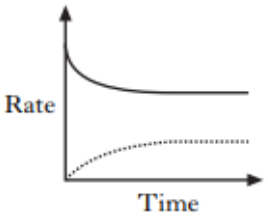
Which of the following graphs shows how the rates of the forward and reverse reactions change when carbon monoxide and steam are mixed?

KEY

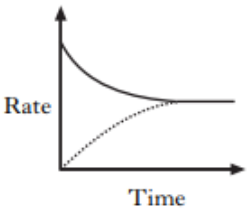
_____ forward reaction

..... reverse reaction

A



B



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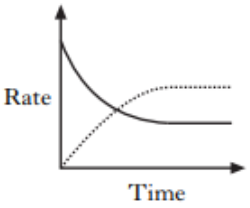
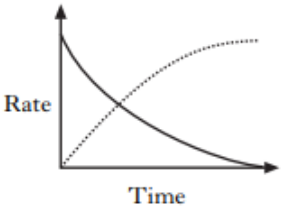


D



51. Which of the following is most likely to act as a reducing agent?

A CO
B MnO_4^-
C H_2O_2
D $Cr_2O_7^{2-}$

52. The following reactions take place when nitric acid is added to zinc.

$$NO_3^-(aq) + 4H^+(aq) + 3e^- \rightarrow NO(g) + 2H_2O(\ell)$$
$$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$$

How many moles of Zn(s) are oxidised by one mole of NO_3^- (aq)?

A 0·67
B 1·0
C 1·5
D 2·0

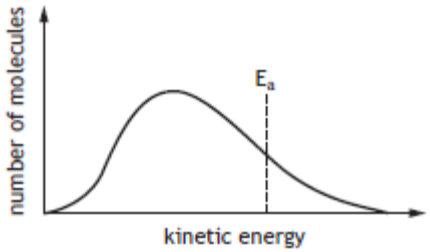
53. Which of the following is not a factor that affects the rate of a reaction?

A Activation energy
B Kinetic energies of reactant molecules
C Concentration of reactants
D Enthalpy change of reaction

54. In which of the following reactions would the yield of product be increased by lowering the pressure?

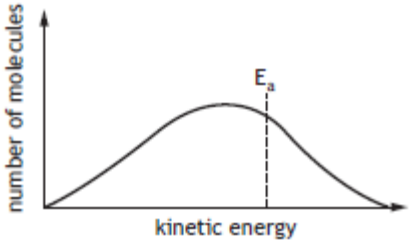
A $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
B $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
C $N_2O_4(g) \rightleftharpoons 2NO_2(g)$
D $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$

55. The graph shows the distribution of kinetic energies for a reaction involving two gases.

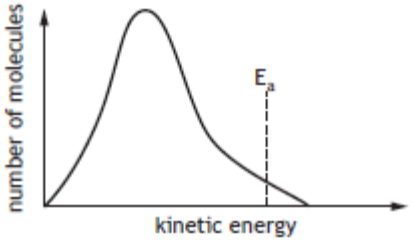


Which graph would show the effect of increasing temperature?

A



B



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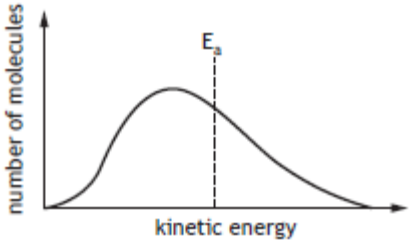
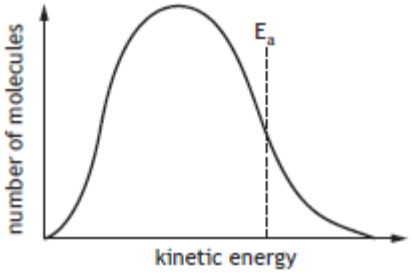
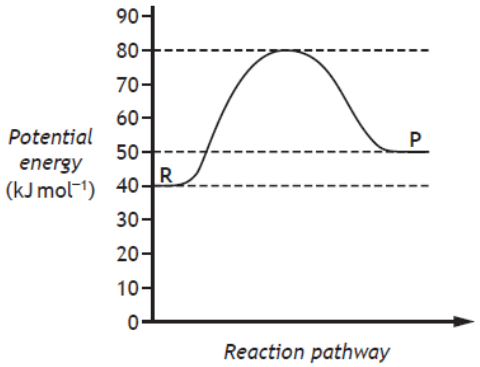


D



56. The potential energy diagram below refers to the reversible reaction involving reactants R and products P.



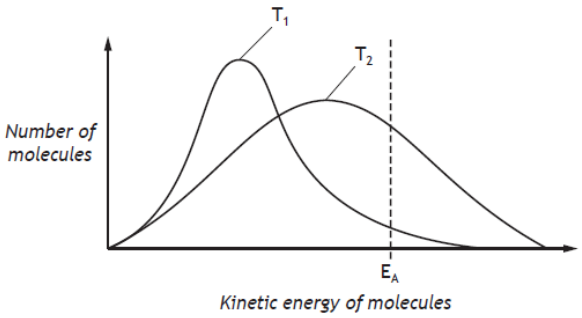
What is the enthalpy change, in kJ mol^{-1}, for the reverse reaction?

A −40
B −10
C +10
D +30

57. The relative rate of a reaction which reached completion in 1 minute 40 seconds is

A 0·010 s^{-1}
B 0·714 s^{-1}
C 0·010 min^{-1}
D 0·714 min^{-1}.

58.



Which of the following is the correct interpretation of the above energy distribution diagram for a reaction as the temperature decreases from T_2 to T_1?

	Activation energy (E_A)	*Number of successful collisions*
A	remains the same	increases
B	decreases	decreases
C	decreases	increases
D	remains the same	decreases

59. $Cl_2(g) + H_2O(\ell) \rightleftharpoons Cl^-(aq) + ClO^-(aq) + 2H^+(aq)$

The addition of which of the following substances would move the above equilibrium to the right?

A Hydrogen

B Hydrogen chloride

C Sodium chloride

D Sodium hydroxide

60. $SO_3^{2-}(aq) + H_2O(\ell) \rightarrow SO_4^{2-}(aq) + 2H^+(aq) + 2e^-$

Which of the following ions could be used to oxidise sulfite ions to sulfate ions?

A $Cr^{3+}(aq)$

B $Al^{3+}(aq)$

C $Fe^{3+}(aq)$

D $Sn^{4+}(aq)$

61. During a redox reaction nitrate ions, NO_3^-, are converted to nitrogen monoxide, NO.

$$NO_3^- \rightarrow NO$$

Which line in the table correctly completes the ion-electron equation?

	Reactants	*Products*
A	$6H^+ + 5e^-$	$3H_2O$
B	$4H^+ + 3e^-$	$2H_2O$
C	$6H^+$	$3H_2O + 5e^-$
D	$4H^+$	$2H_2O + 3e^-$

62. $ICl(\ell) + Cl_2(g) \rightleftharpoons ICl_3(s) \quad \Delta H = -106 kJ\,mol^{-1}$

Which line in the table identifies correctly the changes that will cause the greatest increase in the proportion of solid in the above equilibrium mixture?

	Temperature	*Pressure*
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

63. The enthalpy of combustion of a hydrocarbon is the enthalpy change when

A one mole of a hydrocarbon burns to give one mole of water
B one mole of a hydrocarbon burns to give one mole of carbon dioxide
C one mole of a hydrocarbon burns completely in oxygen
D one mole of a hydrocarbon burns in one mole of oxygen.

64. Which of the following is the strongest reducing agent?

A Fluorine
B Lithium
C Calcium
D Iodine

65. The vitamin C content of a carton of orange juice was determined by four students. Each student carried out the experiment three times.

	Experiment 1 (mg/100 cm^3)	*Experiment 2* (mg/100 cm^3)	*Experiment 3* (mg/100 cm^3)
Student A	30·0	29·0	28·0
Student B	26·4	26·6	26·8
Student C	26·9	27·0	26·9
Student D	26·9	26·5	26·9

The most reproducible results were obtained by

A Student A
B Student B
C Student C
D Student D.

66. Chemical reactions are in a state of dynamic equilibrium only when

A the reaction involves no enthalpy change
B the concentrations of reactants and products are equal
C the activation energies of the forward and backward reactions are equal
D the rate of the forward reaction equals that of the backward reaction.

67. Which line in the table best describes the effect of adding a catalyst to the following reaction?

$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H = -ve$

	Position of equilibrium	*Rate of forward reaction*
A	unchanged	unchanged
B	unchanged	increased
C	moves to right	unchanged
D	moves to right	increased

Unit 3 – Chemistry in Society

Section 2

1.

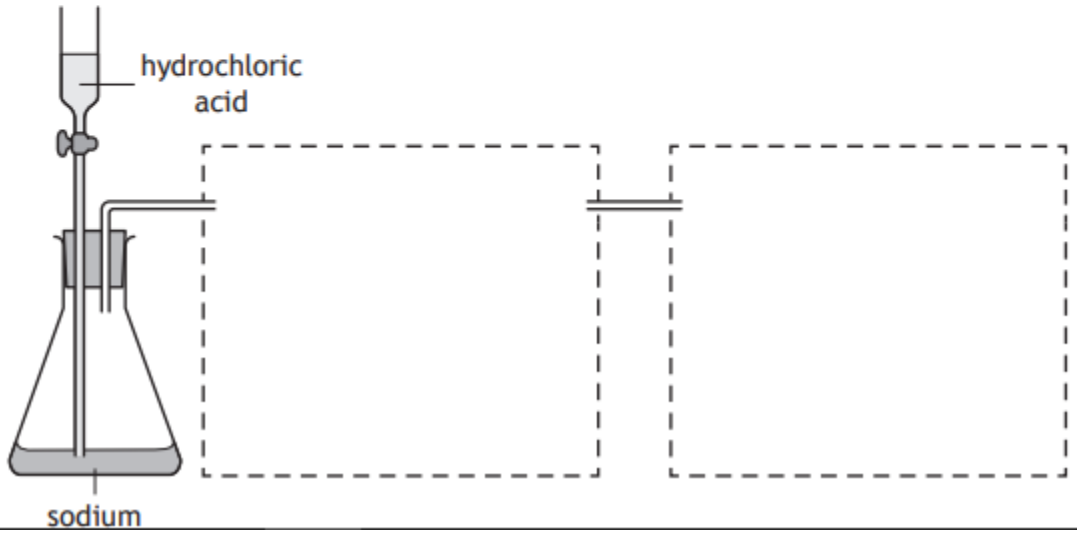
(d) Aluminium, another element in the third period, also forms a chloride. Aluminium chloride is prepared by reacting aluminium metal and chlorine gas.

Chlorine gas is produced by the reaction between hydrochloric acid and sodium hypochlorite. The chlorine is then passed over heated aluminium foil, forming aluminium chloride as a hot gas. The hot aluminium chloride gas and unreacted chlorine gas are passed into a flask where the aluminium chloride cools to a fine white powder.

For safety it is important that any unreacted chlorine gas can escape from the flask.

(i) Complete a labelled diagram to show an apparatus suitable for carrying out this preparation. **2**

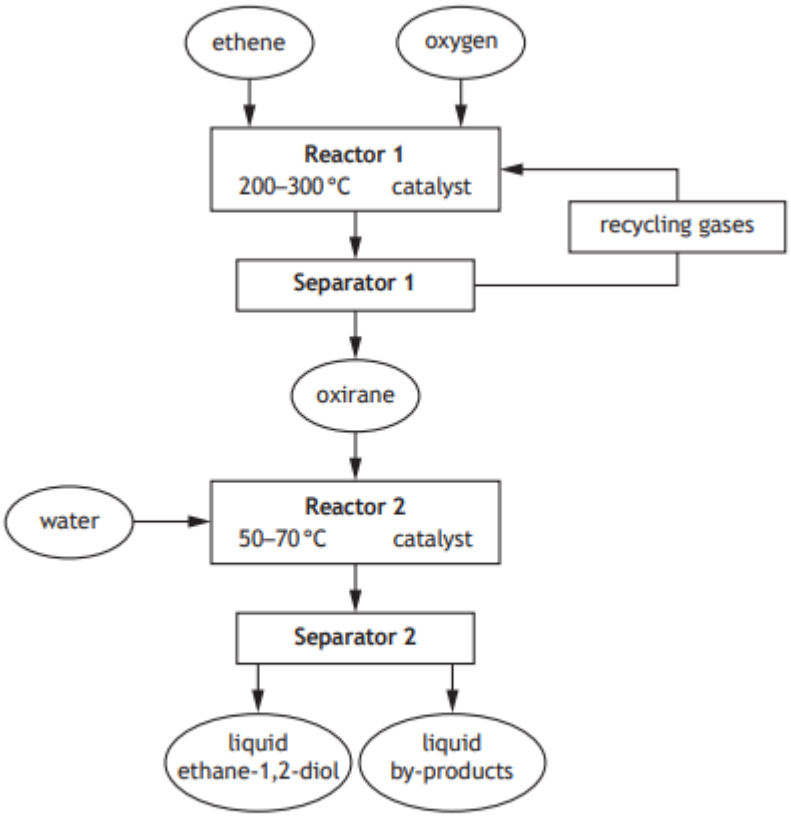
(An additional diagram, if required, can be found on *page 37*).



(ii) Explain why the aluminium foil needs to be heated at the start of the preparation, despite the reaction being highly exothermic. **1**

2.

(a) The flow chart of an industrial process to produce ethane-1,2-diol is shown.



(i) Industrial processes are designed to maximise profit.

Using the flowchart, suggest two ways to maximise profit in this industrial process. **2**

(a) (continued)

(ii) Name the process used in **Separator 2** to separate ethane-1,2-diol from the larger liquid by-products. **1**

3.

(d) Ethane-1,2-diol has been found to be harmful to animals. Treatment for affected animals involves using a 20% ethanol solution.

(i) The 20% ethanol solution is prepared by accurately measuring 20 cm^3 of ethanol and then making up to exactly 100 cm^3 with water.

Describe the procedure which should be used to prepare 100 cm^3 of the 20% ethanol solution. **2**

4.

Iodine is required for a healthy diet. Food grown in certain parts of the world is low in iodine. To prevent iodine deficiency in people's diets, table salt can be 'iodised' by the addition of very small quantities of potassium iodide, KI.

The number of moles of iodide in a sample of salt can be determined by the following procedure.

Step 1

Prepare a standard salt solution by dissolving an accurately weighed sample of iodised salt (50·0 g) in water to give a final volume of 250 cm^3.

Step 2

Transfer 50 cm^3 of salt solution to a conical flask and add excess bromine solution to convert the iodide ions to iodine.

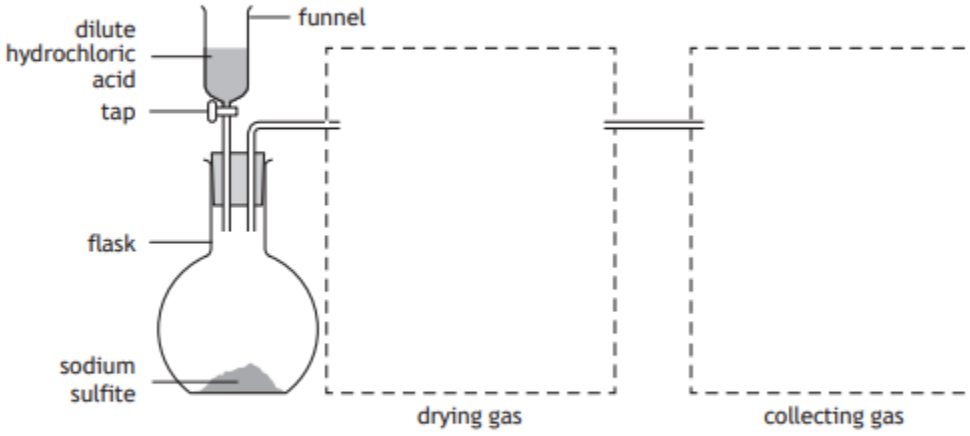
Step 3

Titrate the iodine (I_2) released with sodium thiosulfate solution ($Na_2S_2O_3$).

(a) Describe a procedure to accurately weigh out a 50·0 g sample of iodised table salt. **1**

5. Sulfur dioxide is a colourless, toxic gas that is soluble in water and more dense than air.

(a) One laboratory method for preparation of sulfur dioxide gas involves adding dilute hydrochloric acid to solid sodium sulfite. The sulfur dioxide gas produced is dried by bubbling the gas through concentrated sulfuric acid. The sulfur dioxide gas can then be collected.



MARKS

(i) Complete the diagram by drawing:

in the first box, apparatus suitable for drying the sulfur dioxide gas;

in the second box, apparatus suitable for collecting the gas. **2**

6.

Reactions involving iodine are commonly used to investigate rates of reaction.

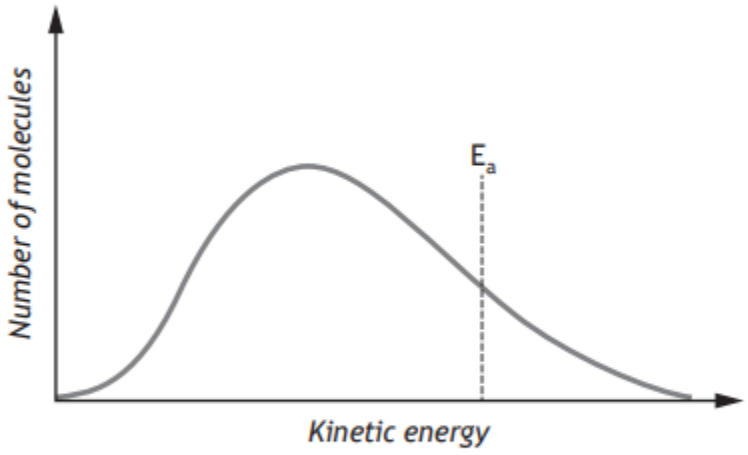
(a) One reaction involves hydrogen and iodine reacting together to form hydrogen iodide.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

(i) This reaction is thought to occur by initially breaking bonds in one of the reactants.

Explain, using bond enthalpies, which bond is more likely to break first during this reaction. **1**

(ii) The graph shows the distribution of kinetic energies of reactant molecules in the gas mixture at 300 °C.



Add a second curve to the graph to show the distribution of kinetic energies at 400 °C. **1**

(An additional graph, if required, can be found on *Page 35*)

(a) (continued)

(iii) The reaction to produce hydrogen iodide is exothermic.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

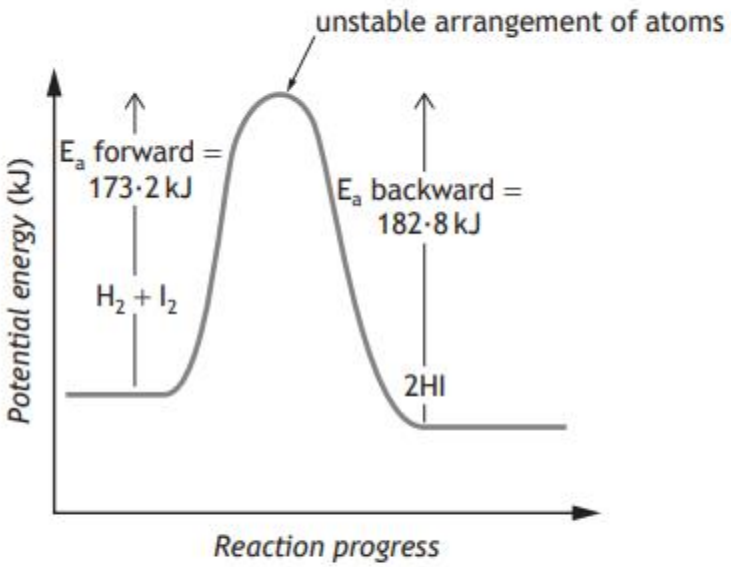
(A) State the effect of increasing temperature on the position of equilibrium. **1**

(B) State why changing the pressure has no effect on this equilibrium reaction. **1**

6.

(a) (continued)

(iv) The potential energy diagram for the reaction between hydrogen and iodine is shown.



(A) State the term for the unstable arrangement of atoms. **1**

(B) Calculate the enthalpy change, in kJ, for the forward reaction. **1**

(C) Platinum can be used as a catalyst for this reaction.

State the effect that platinum would have on the activation energy for the reaction. **1**

7. Some people take iron tablets as a dietary supplement. Iron tablets may contain iron(II) sulfate.

(a) A student was investigating the iron(II) content of iron tablets. A work card gave the following instructions for preparing an iron tablet solution.

1. Add five iron tablets to about 50 cm^3 of dilute sulfuric acid in a small beaker and stir to dissolve.
2. Transfer quantitatively to a 100 cm^3 volumetric flask.
3. Make up the solution to the graduation mark on the volumetric flask.
4. Stopper the flask and then invert it to mix the solution.

To 'transfer quantitatively' means that **all** of the iron tablet solution must be transferred into the volumetric flask.

Describe how this is carried out in practice. **1**

(b) The concentration of iron(II) ions (Fe^{2+}) in this iron tablet solution can be determined by a redox titration with permanganate (MnO_4^-) solution.

$$5Fe^{2+}(aq) + 8H^+(aq) + MnO_4^-(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(\ell)$$

(i) Suggest why it is **not** necessary to add an indicator to this titration. **1**

7. (b) (continued)

(ii) Suggest why the titration must be carried out under acidic conditions. **1**

(iii) Three 25·0 cm^3 samples of the iron tablet solution were titrated with a standard solution of 0·020 mol l^{-1} permanganate (MnO_4^-). The results are shown below.

Sample	*Volume of permanganate* (cm^3)
1	14·9
2	14·5
3	14·6

(A) State why the volume of permanganate used in the calculation was taken to be 14·55 cm^3, although this is not the average of the three titres in the table. **1**

7. (b) (iii) (continued)

(C) State what is meant by the term **standard solution**. **1**

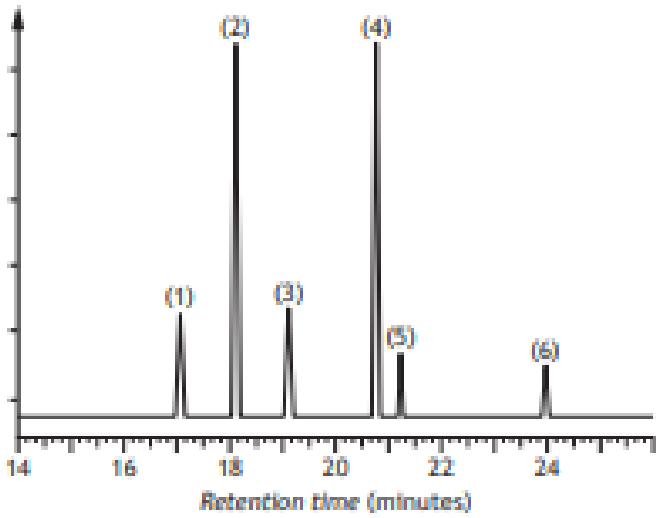
(D) Name an appropriate piece of apparatus which could be used to measure 25·0 cm^3 samples of iron tablet solution. **1**

8.

. Essential oils from the lavender plant are used in aromatherapy. MARKS

(a) Gas chromatography can be used to separate and identify the organic compounds in lavender oils.

Chromatogram 1 - Lavender oil **A**



Peak	*Component*	*Component peak area*
1	1,8-cineole	7432
2	linalool	31 909
3	camphor	7518
4	linalyl acetate	27 504
5	geranyl acetate	3585
6	farnesene	1362

Total peak area = 79 310

The relative concentration of each component can be calculated using the following formula.

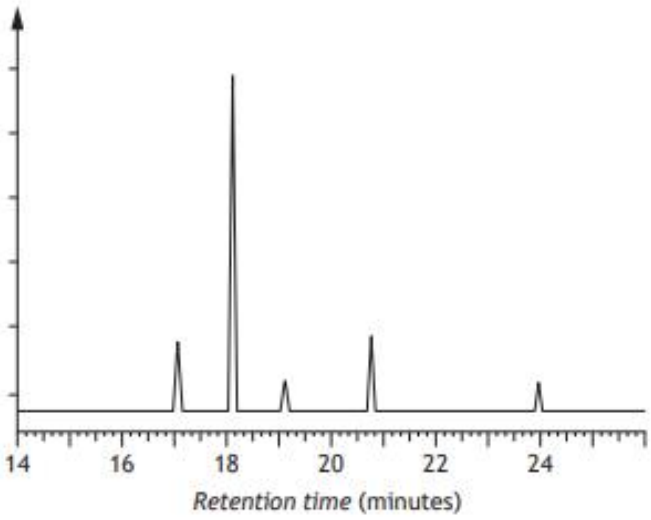
$$\text{Relative concentration} = \frac{\text{Component peak area}}{\text{Total peak area}} \times 100\ (\%)$$

(i) Calculate the relative concentration of linalool in lavender oil **A**. 1

(a) (continued)

(ii) Different varieties of lavender oils have different compositions.

Chromatogram 2 – Lavender oil **B**



Identify the component found in lavender oil **A** that is missing from lavender oil **B**. **1**

9.

Hydrogen peroxide gradually decomposes into water and oxygen, according to the following equation.

$$2H_2O_2(aq) \rightarrow 2H_2O(\ell) + O_2(g)$$

(a) At room temperature, the reaction is very slow. It can be speeded up by heating the reaction mixture.

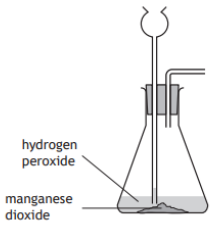
State why increasing the temperature causes an increase in reaction rate. **1**

(b) (i) The reaction can also be speeded up by adding a catalyst, such as manganese dioxide.

To determine the rate of the reaction, the volume of gas produced in a given time can be measured.

Complete the diagram below to show how the gas produced can be collected and measured. **1**

(An additional diagram, if required, can be found on *Page 38*).



10.

(d) Paper chromatography is often used to analyse the mixtures of amino acids produced when peptides are broken down.

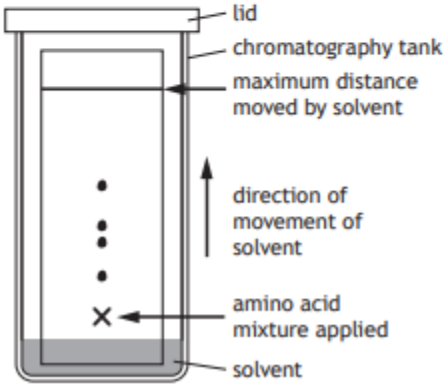
On a chromatogram, the retention factor R_f, for a substance can be a useful method of identifying the substance.

$$R_f = \frac{\text{distance moved by the substance}}{\text{maximum distance moved by the solvent}}$$

The structure of the pentapeptide methionine enkephalin was investigated.

A sample of the pentapeptide was completely hydrolysed into its constituent amino acids and this amino acid mixture was applied to a piece of chromatography paper and placed in a solvent.

The chromatogram obtained is shown below.



(i) Suggest why only four spots were obtained on the chromatogram of the hydrolysed pentapeptide. **1**

(ii) It is known that this amino acid mixture contains the amino acid methionine. The R_f value for methionine in this solvent is 0·40.

Draw a circle around the spot on the chromatogram that corresponds to methionine. **1**

11.

(a) Methanol is produced from methane in a two-step process.

In step 1, methane is reacted with steam as shown.

Step 1: $CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g) \quad \Delta H = +210\,kJ\,mol^{-1}$

In step 2, hydrogen reacts with carbon monoxide.

Step 2: $2H_2(g) + CO(g) \rightleftharpoons CH_3OH(g) \quad \Delta H = -91\,kJ\,mol^{-1}$

Complete the table to show the most favourable conditions to maximise the yield for each step. **2**

	Temperature (High/Low)	*Pressure* (High/Low)
Step 1		
Step 2		

(ii) The atom economy of this reaction is 100%.
Explain what this means. **1**

12.

Soft drinks contain a variety of sugars. A student investigated the sugar content of a soft drink.

(a) The density of the soft drink can be used to estimate its total sugar concentration. Solutions of different sugars, with the same concentration, have similar densities.

The first experiment was to determine the total sugar concentration of the soft drink by comparing the density of the drink with the density of standard sucrose solutions.

(i) This firstly involved producing standard sucrose solutions of different concentrations.

The standard sucrose solutions were made up in volumetric flasks.

Draw a diagram of a volumetric flask. **1**

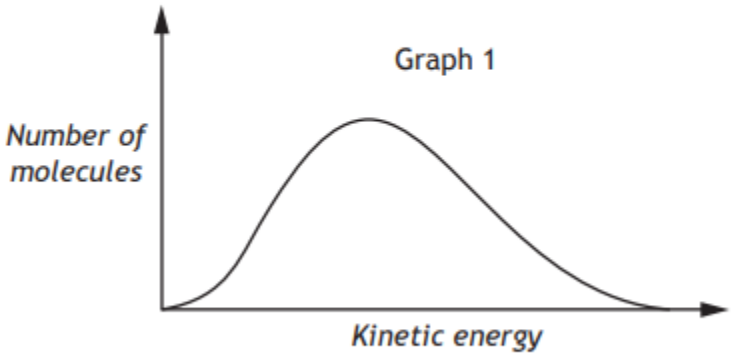
the student accurately measured the mass of 10·0 cm^3 of each sucrose solution.

Describe **fully** a method that the student could have used to accurately measure the mass of 10·0 cm^3 of each sucrose solution. **2**

13.

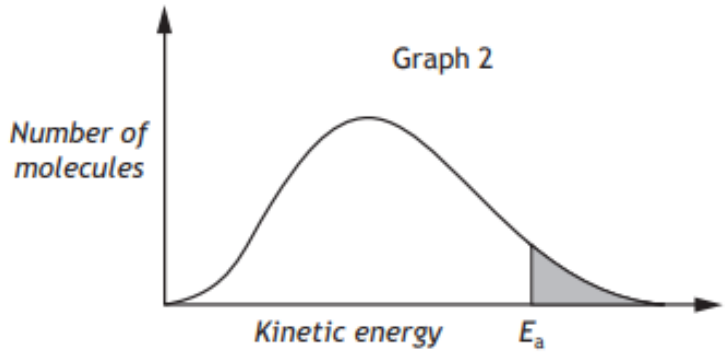
(b) The rate of reaction can also be altered by changing the temperature or using a catalyst.

(i) Graph 1 shows the distribution of kinetic energies of molecules in a gas at 100 °C.



Add a second curve to graph 1 to show the distribution of kinetic energies at 50 °C. **1**

(ii) In graph 2, the shaded area represents the number of molecules with the required activation energy, E_a.



Draw a line to show how a catalyst affects the activation energy. **1**

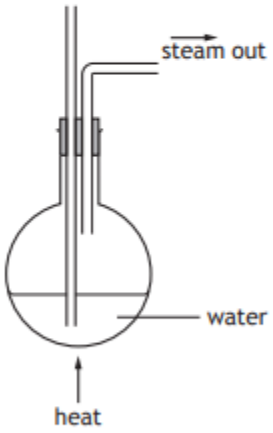
14.

3. (a) Methyl cinnamate is an ester used to add strawberry flavour to foods. It is a naturally occurring ester found in the essential oil extracted from the leaves of strawberry gum trees.

To extract the essential oil, steam is passed through shredded strawberry gum leaves. The steam and essential oil are then condensed and collected.

(i) Complete the diagram to show an apparatus suitable for carrying out this extraction. **2**

(An additional diagram, if required, can be found on *Page thirty-seven*).



(ii) The essential oil extracted is a mixture of compounds.

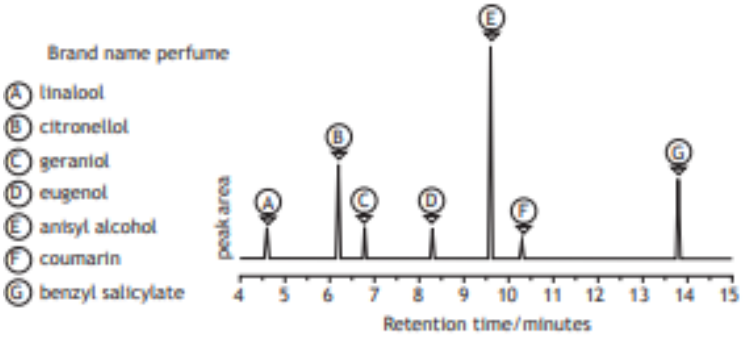
Suggest a technique that could be used to separate the mixture into pure compounds. **1**

15.

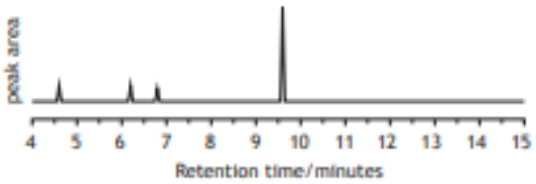
4. Up to 10% of perfumes sold in the UK are counterfeit versions of brand name perfumes.

One way to identify if a perfume is counterfeit is to use gas chromatography. Shown below are gas chromatograms from a brand name perfume and two different counterfeit perfumes. Some of the peaks in the brand name perfume have been identified as belonging to particular compounds.

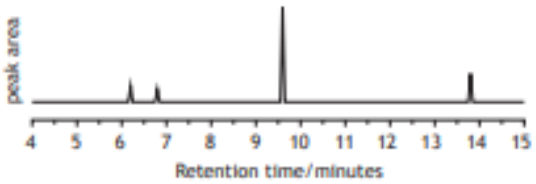
Brand name perfume



Counterfeit A



Counterfeit B



(a) Identify one compound present in the brand name perfume that appears in both counterfeit perfumes. 1

(b) Some compounds in the brand name perfume are not found in the counterfeit perfumes. State another difference that the chromatograms show between the counterfeit perfumes and the brand name perfume. 1

(c) The gas used to carry the perfume sample along the chromatography column is helium.

(i) Suggest why helium is used. 1

(ii) Apart from the polarity of the molecules, state another factor that would affect the retention time of molecules during gas chromatography. 1

16.

Sodium carbonate is used in the manufacture of soaps, glass and paper as well as the treatment of water. MARKS

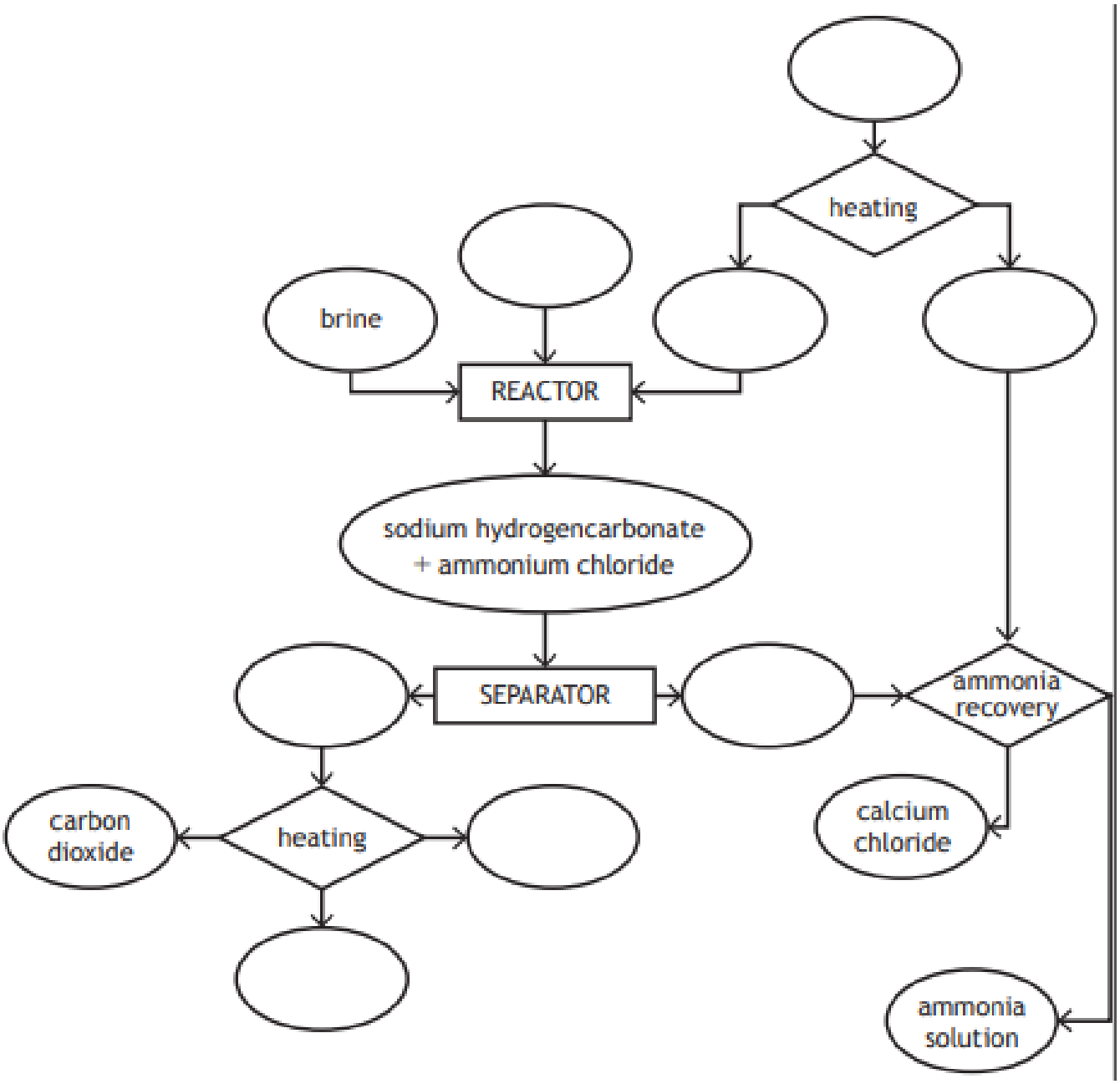
One industrial process used to make sodium carbonate is the Solvay process.

The Solvay process involves several different chemical reactions.

It starts with heating calcium carbonate to produce carbon dioxide, which is transferred to a reactor where it reacts with ammonia and brine. The products of the reactor are solid sodium hydrogencarbonate and ammonium chloride which are passed into a separator.

The sodium hydrogencarbonate is heated to decompose it into the product sodium carbonate along with carbon dioxide and water. To recover ammonia the ammonium chloride from the reactor is reacted with calcium oxide produced by heating the calcium carbonate. Calcium chloride is a by-product of the ammonia recovery process.

(a) Using the information above, complete the flow chart by adding the names of the chemicals involved. 2



(b) The reaction that produces the solid sodium hydrogencarbonate involves the following equilibrium:

$$HCO_3^-(aq) + Na^+(aq) \rightleftharpoons NaHCO_3(s)$$

Brine is a concentrated sodium chloride solution.

Explain fully why using a concentrated sodium chloride solution encourages production of sodium hydrogencarbonate as a solid. **2**

17.

Plants require trace metal nutrients, such as zinc, for healthy growth. Zinc ions are absorbed from soil through the plant roots.

The zinc ion concentration in a solution can be found by adding a compound which gives a blue colour to the solution with zinc ions. The concentration of zinc ions is determined by measuring the absorption of light by the blue solution. The higher the concentration of zinc ions in a solution, the more light is absorbed.

A student prepared a stock solution with a zinc ion concentration of $1\,g\,l^{-1}$. Samples from this were diluted to produce solutions of known zinc ion concentration.

(a) The stock solution was prepared by adding 1·00 g of zinc metal granules to $20\,cm^3$ of 2 mol l^{-1} sulfuric acid in a $1000\,cm^3$ standard flask.

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

The flask was left for 24 hours, without a stopper. The solution was then diluted to 1000 cm^3 with water.

(i) **Explain fully** why the flask was left for 24 hours, without a stopper. **2**

(ii) Explain why the student should use deionised water or distilled water, rather than tap water, when preparing the stock solution. **1**

(b) Solutions of known zinc ion concentration were prepared by transferring accurate volumes of the stock solution to standard flasks and diluting with water.

(i) Name the piece of apparatus which should be used to transfer $10\,cm^3$ of stock solution to a standard flask. **1**

18.

12. (a) The concentration of sodium hypochlorite in swimming pool water can be determined by redox titration.

Step 1

A $100{\cdot}0\,cm^3$ sample from the swimming pool is first reacted with an excess of acidified potassium iodide solution forming iodine.

$$NaOCl(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + NaCl(aq) + H_2O(\ell)$$

Step 2

The iodine formed in step 1 is titrated using a standard solution of sodium thiosulfate, concentration 0·00100 mol l^{-1}. A small volume of starch solution is added towards the endpoint.

$$I_2(aq) + 2Na_2S_2O_3(aq) \rightarrow 2NaI(aq) + Na_2S_4O_6(aq)$$

(i) Describe in detail how a burette should be prepared and set up, ready to begin the titration. **3**

19.

A student carried out an investigation to measure the fluoride and nitrite levels in a water supply.

(a) The student prepared a set of sodium fluoride solutions of known concentration by diluting a standard solution.

(i) State what is meant by the term **standard solution**. **1**

(iii) Describe how the standard solution would be prepared from the weighed sample of sodium fluoride. **3**

(iv) Suggest why the student should use distilled or deionised water rather than tap water when dissolving the sodium fluoride. **1**

(b) The concentration of nitrite ions, NO_2^-, in the water supply was determined by titrating water samples with acidified permanganate solutions.

The reaction taking place is

$$2MnO_4^-(aq) + 5NO_2^-(aq) + 6H^+(aq) \rightarrow 2Mn^{2+}(aq) + 5NO_3^-(aq) + 3H_2O(\ell)$$

(i) Name the most appropriate piece of laboratory apparatus to measure out 25·0 cm^3 samples of water. **1**

20.

(c) In one method that can be used to measure the concentration of hypochlorite ions in a sample of bleach, the bleach sample is reacted with excess hydrogen peroxide.

$$H_2O_2(aq) + ClO^-(aq) \rightarrow H_2O(\ell) + Cl^-(aq) + O_2(g)$$

By measuring the volume of oxygen given off, the concentration of bleach can be calculated.

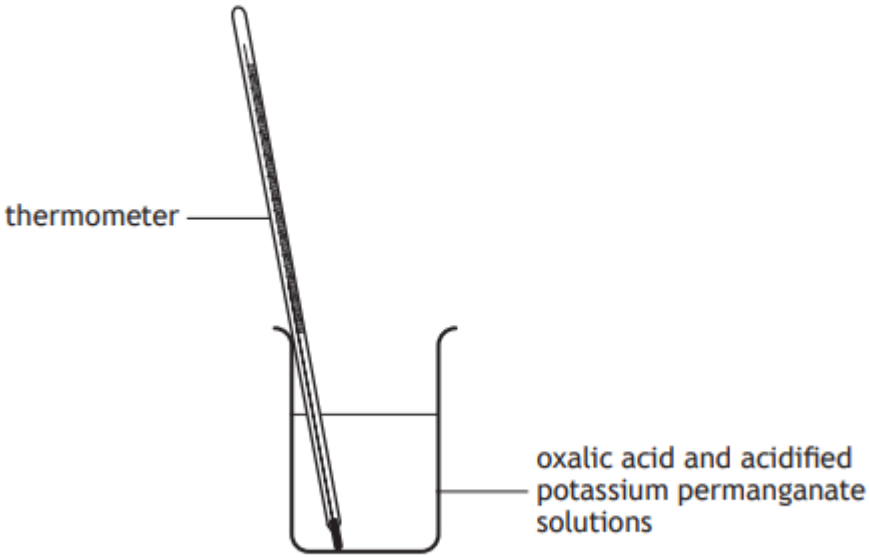
(i) Draw a diagram showing an assembled apparatus that could be used to react hydrogen peroxide solution with bleach and measure the volume of oxygen gas released.

Your diagram should include labels showing the names and positions of the reacting chemicals and the collected product. **3**

21.

Changing the temperature at which a redox reaction is carried out changes the rate of reaction.

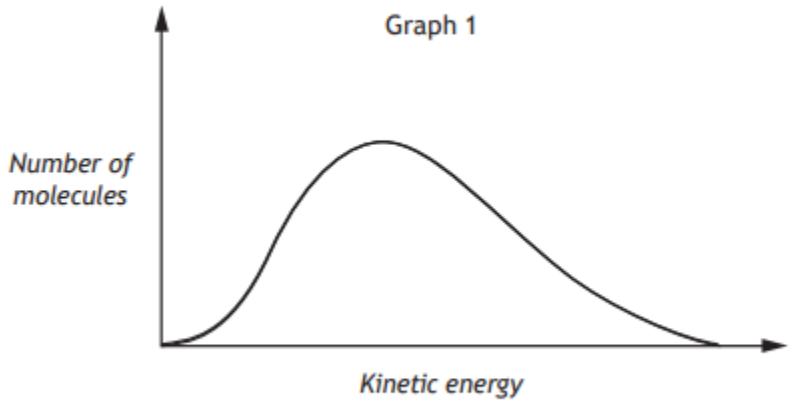
(a) The effect of temperature on reaction rate can be studied using the rate at which acidified potassium permanganate is reduced by oxalic acid.



(i) State the colour change that takes place when acidified permanganate ions are reduced. **1**

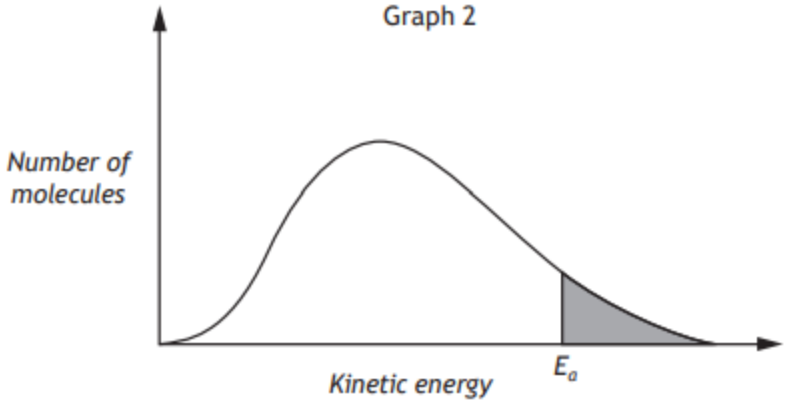
(b) (i) Graph 1 shows the distribution of kinetic energy of molecules in a gas at 100 °C.

Graph 1



Add a second curve to Graph 1 to show the distribution of kinetic energies at 50 °C. **1**

(ii) In Graph 2, the shaded area represents the number of molecules with the required activation energy, E_a.



Draw a line to show how a catalyst affects the activation energy. **1**

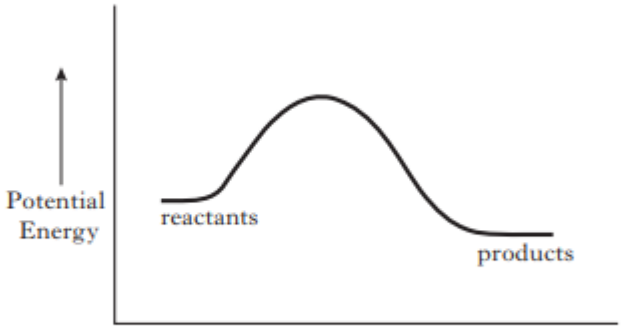
(An additional graph, if required, can be found on *page 39*.)

(c) A collision involving molecules with the required energy of activation may **not** result in a reaction.

State a reason for this. **1**

22.

(ii) The diagram below represents the changing potential energy during this reaction carried out without the palladium catalyst.



Add a line to the diagram showing the changing potential energy when the catalyst is used. **1**

23.

In many bathroom cleaning products, the bleaching agent is the hypochlorite ion, $ClO^-(aq)$.

(*a*) Hypochlorite bleaches can be made by reacting sodium hydroxide with chlorine. Sodium hypochlorite, sodium chloride and water are formed.

Write a balanced equation for the reaction.

2

(*b*) In the bleach solution, the following equilibrium exists.

$$Cl_2(aq) + H_2O(\ell) \rightleftharpoons 2H^+(aq) + ClO^-(aq) + Cl^-(aq)$$

Explain why the addition of sodium hydroxide increases the bleaching efficiency of the solution.

24.

A student carried out an investigation to measure the nitrite level in the school water supply.

A compound, which reacts with the nitrite ions to form a product that absorbs light, is added to water samples. The higher the concentration of nitrite ions present in a water sample, the greater the amount of light absorbed.

(ii) Describe how the weighed potassium nitrate is dissolved to prepare the stock solution to ensure that its concentration is accurately known.

(iii) Why should the student use distilled or deionised water rather than tap water when dissolving the potassium nitrite?

(iv) To prepare a solution with a nitrite ion concentration of 0·05 mg l^{-1} the student dilutes the stock solution. Why is this method more accurate than preparing a solution by weighing out potassium nitrite?

1

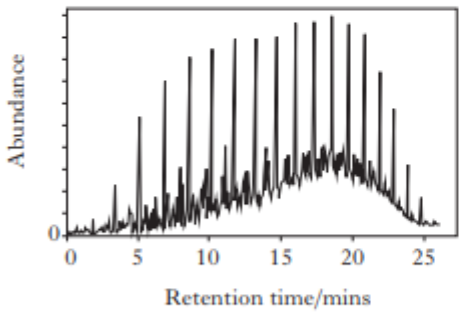
25.

11. When a fire has been started deliberately, gas liquid chromatography (GLC) can be used to identify the tiny amounts of fuel or flammable liquid used to help start the fire.

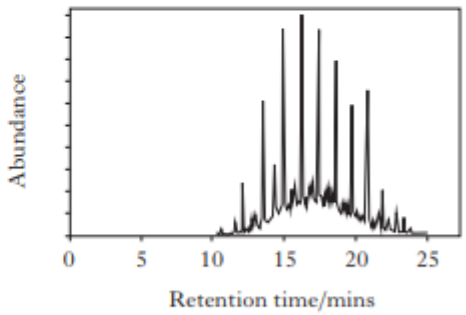
(*a*) Diesel contains a mixture of non-polar molecules of different sizes.

Below are the chromatograms recorded using a normal sample of diesel and a sample of diesel that has been heated until around 90% of the diesel had evaporated.

Fresh diesel



Diesel residue after evaporation



Explain how these chromatograms show that large molecules have longer retention times than small molecules in this type of chromatography.

(*b*) A suspicious house fire was found to have started in a chair.

An almost empty bottle of paint thinner was found in a suspect's car.

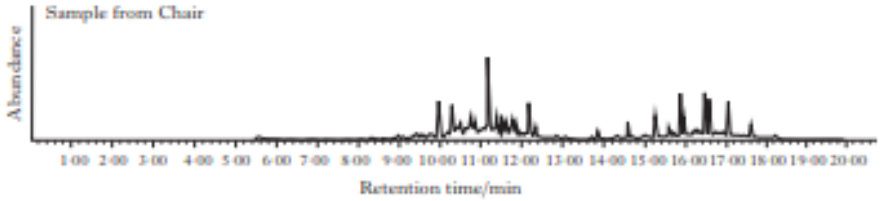
In the house there were two cans of furniture polish which might have been used to clean the chair at some time.

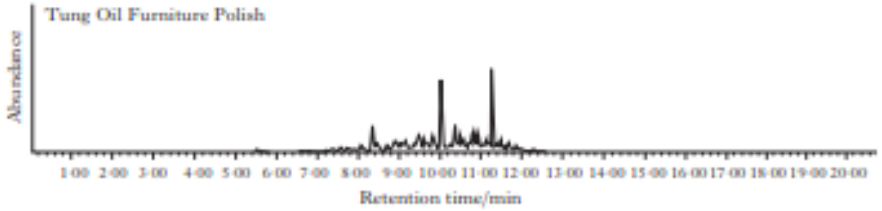
The chromatograms obtained from the remains of the chair, the paint thinner and the furniture polishes are shown opposite.

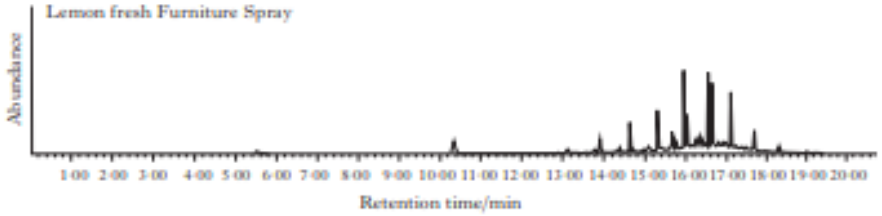
Which of the substances tested were present on the armchair?

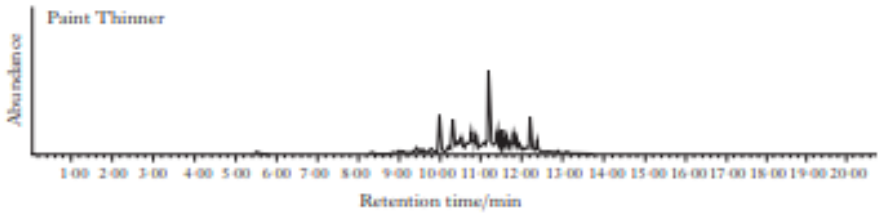
1

11. (continued)









26.

(*c*) Hydrogen sulfide, H_2S, can cause an unpleasant smell in water supplies.

The concentration of hydrogen sulfide can be measured by titrating with a chlorine standard solution.

The equation for the reaction taking place is

$$4Cl_2(aq) + H_2S(aq) + 4H_2O(\ell) \rightarrow SO_4^{2-}(aq) + 10H^+(aq) + 8Cl^-(aq)$$

50·0 cm^3 samples of water were titrated using a 0·010 mol l^{-1} chlorine solution.

(i) Name an appropriate piece of apparatus which could be used to measure out the water samples.

1

(ii) What is meant by the term **standard solution**?

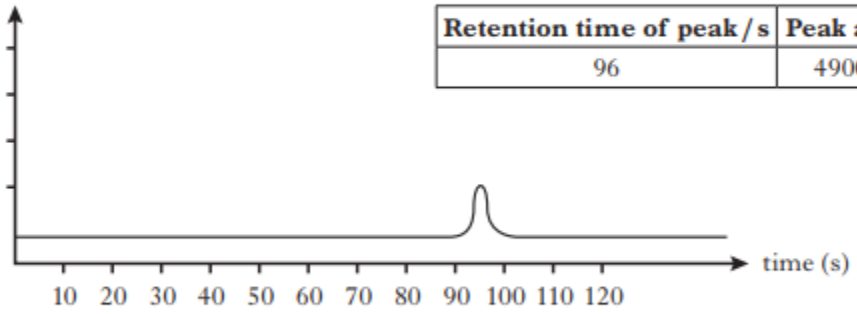
1

27.

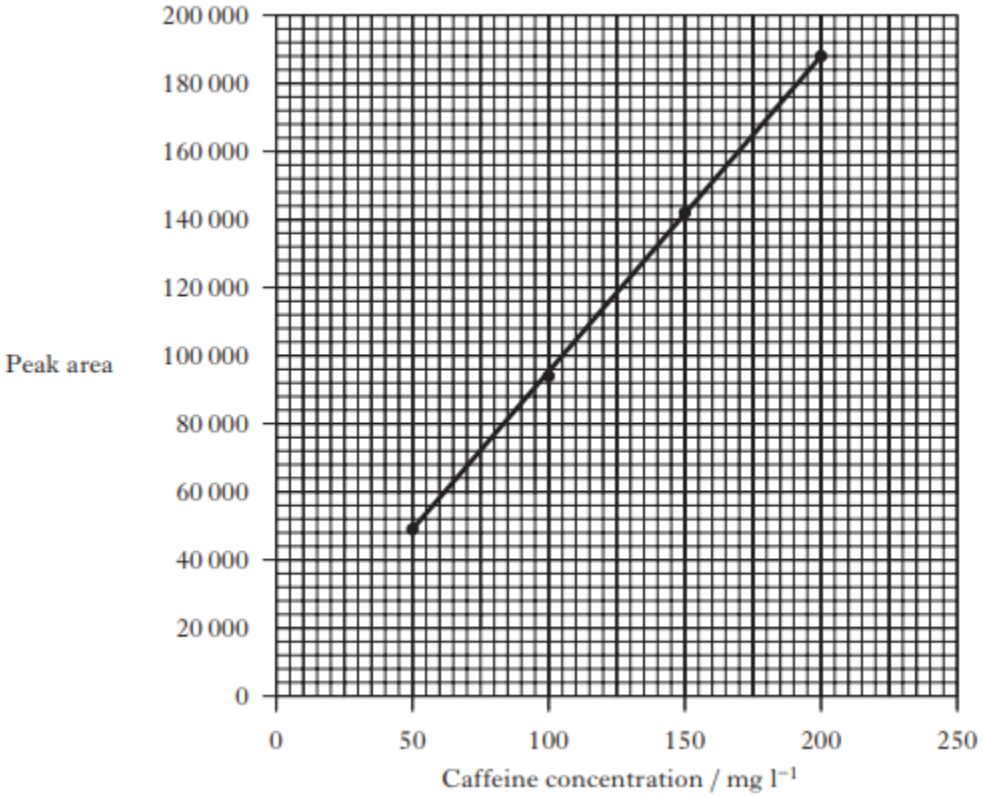
(*b*) Caffeine is also added to some soft drinks. The concentration of caffeine can be found using chromatography.

A chromatogram for a standard solution containing 50 mg l^{-1} of caffeine is shown below.

Retention time of peak / s	Peak area
96	49000



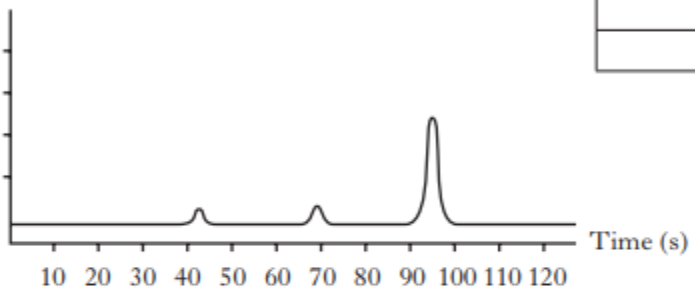
Results from four caffeine standard solutions were used to produce the calibration graph below.


Peak area
200 000
180 000
160 000
140 000
120 000
100 000
80 000
60 000
40 000
20 000
0
0
50
100
150
200
250
Caffeine concentration / mg l−1

9. (*b*) (continued)

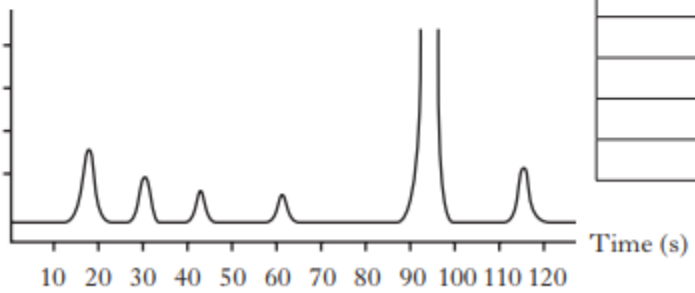
Chromatograms for two soft drinks are shown below.

Soft drink **X**



Retention time of peak / s	Peak area
42	1000
69	1350
96	68000

Soft drink **Y**



Retention time of peak / s	Peak area
17	7000
30	4600
43	3000
62	2500
96	———
115	5000

(i) What is the caffeine content, in mg l^{-1} of soft drink **X**?

(ii) The caffeine content of the soft drink **Y** cannot be determined from its chromatogram.

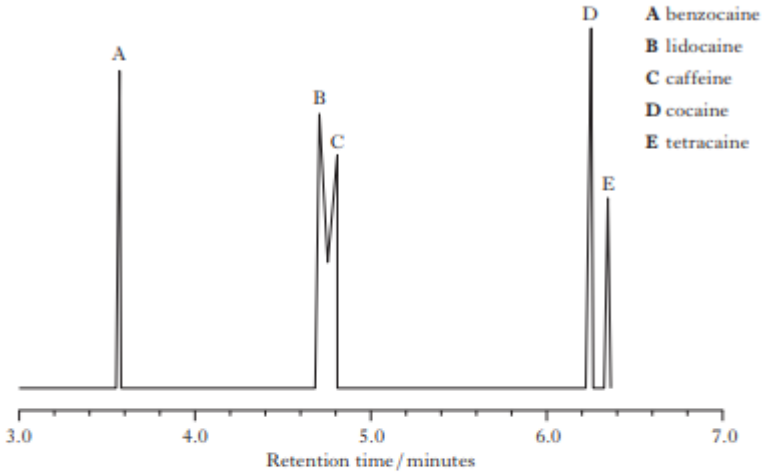
What should be done to the sample of soft drink **Y** so that the caffeine content could be reliably calculated?

1

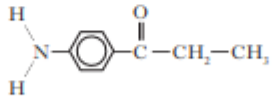
28.

(*d*) When forensic scientists analyse illegal drugs, anaesthetics such as lidocaine are sometimes found to be present.

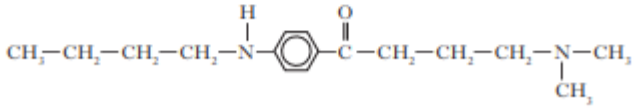
The gas chromatogram below is from an illegal drug.



(i) The structures of benzocaine and tetracaine are shown below.



benzocaine



tetracaine

Suggest why benzocaine has a shorter retention time than tetracaine.

(*d*) (continued)

(ii) Why is it difficult to obtain accurate values for the amount of lidocaine present in a sample containing large amounts of caffeine?

29.

Hydrogen sulfide is a toxic gas with the smell of rotten eggs.

(*a*) Hydrogen sulfide gas can be prepared by the reaction of iron(II) sulfide with excess dilute hydrochloric acid:

$$FeS(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2S(g)$$

(i) Hydrogen sulfide gas is very soluble in water.

Draw a diagram to show an assembled apparatus that could be used to measure the volume of H_2S gas produced when a sample of iron(II) sulfide reacts with hydrochloric acid.

Your diagram should be labelled and should show the names of any chemicals used.

30.

(*b*) In the second stage, the carbon monoxide and hydrogen react to produce methanol.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \quad \Delta H = -91 \text{ kJ mol}^{-1}$$

Circle the correct words in the table to show the changes to temperature and pressure that would favour the production of methanol.

(An additional table, if required, can be found on *Page thirty-four*.)

temperature	decrease / keep the same / increase
pressure	decrease / keep the same / increase

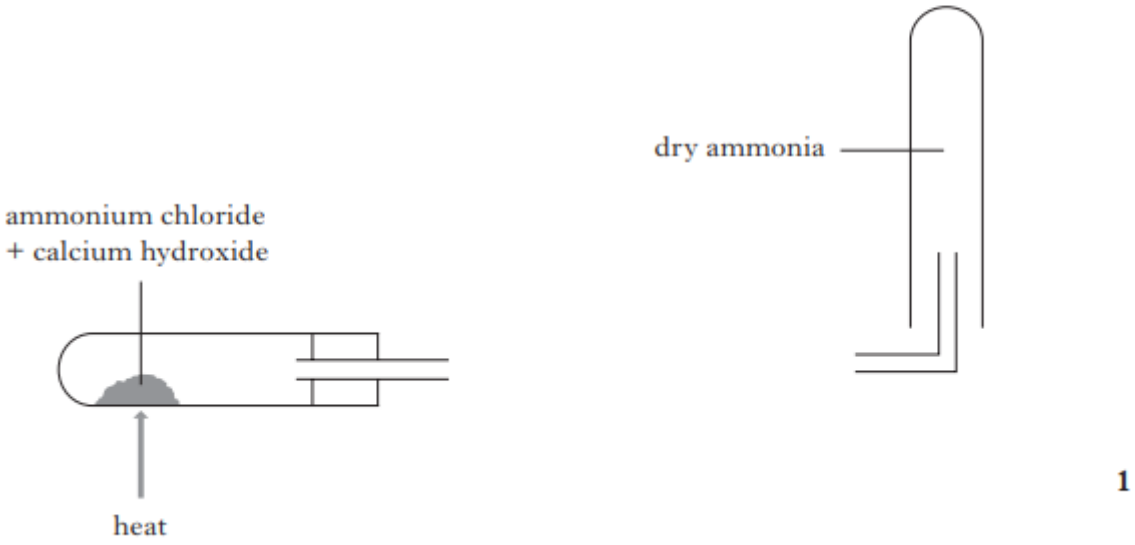
1

31.

(*a*) A small sample of ammonia can be prepared in the laboratory by heating a mixture of ammonium chloride and calcium hydroxide. The ammonia is dried by passing it through small lumps of calcium oxide and collected by the downward displacement of air.

Complete the diagram to show how ammonia gas can be dried before collection.

(An additional diagram, if required, can be found on *Page thirty-six*.)



1

32.

(ii) Some students carried out an investigation of fruit drinks to determine their vitamin C content. The following steps were followed in each experiment.

Step 1 A 20·0 cm^3 sample of fruit drink was transferred to a conical flask by pipette.

Step 2 A burette was filled with a standard iodine solution.

Step 3 The fruit drink sample was titrated with the iodine.

Step 4 Titrations were repeated until concordant results were obtained.

The burette, pipette and conical flask were all rinsed before they were used.

Tick the appropriate boxes below to show which solution should be used to rinse each piece of glassware.

Glassware used	Rinse with water	Rinse with iodine	Rinse with fruit drink
pipette			
burette			
conical flask			

2

(iii) Titrating a whole carton of fruit drink would require large volumes of iodine solution.

Apart from this disadvantage, give another reason for titrating several smaller samples of fruit drink.

1

33.

(*b*) Collision theory can be used to explain reaction rates.

Collision theory states that for two molecules to react, they must first collide with one another.

State **two** conditions necessary for the collisions to result in the formation of products.

34.

(*b*) When light is shone through a permanganate solution some of the light is absorbed.

The concentration of a permanganate solution can be found by measuring the amount of light absorbed and comparing this with the light absorbed by solutions of known concentration.

(i) To obtain solutions of known concentration a stock solution of accurately known concentration is first prepared.

Describe how a stock solution of accurately known concentration could be prepared from a weighed sample of potassium permanganate crystals.

2

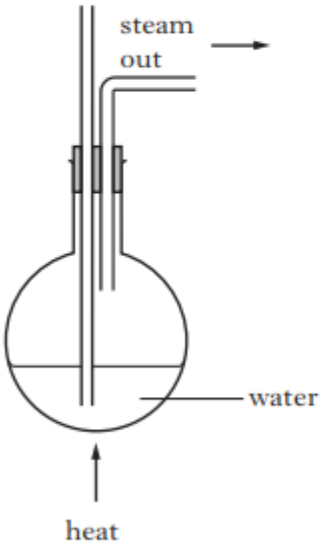
35.

2. (*a*) Methyl cinnamate is an ester used to add strawberry flavour to foods. It is a naturally occurring ester found in the essential oil extracted from the leaves of strawberry gum trees.

To extract the essential oil, steam is passed through shredded strawberry gum leaves. The steam and essential oil are then condensed and collected.

(i) Complete the diagram to show an apparatus suitable for carrying out this extraction.

(An additional diagram, if required, can be found on *Page thirty-three*.)



2

(ii) The essential oil extracted is a mixture of compounds.

Suggest a technique that could be used to separate the mixture into pure compounds.

36.

Sodium carbonate is used in the manufacture of soaps, glass and paper as well as the treatment of water.

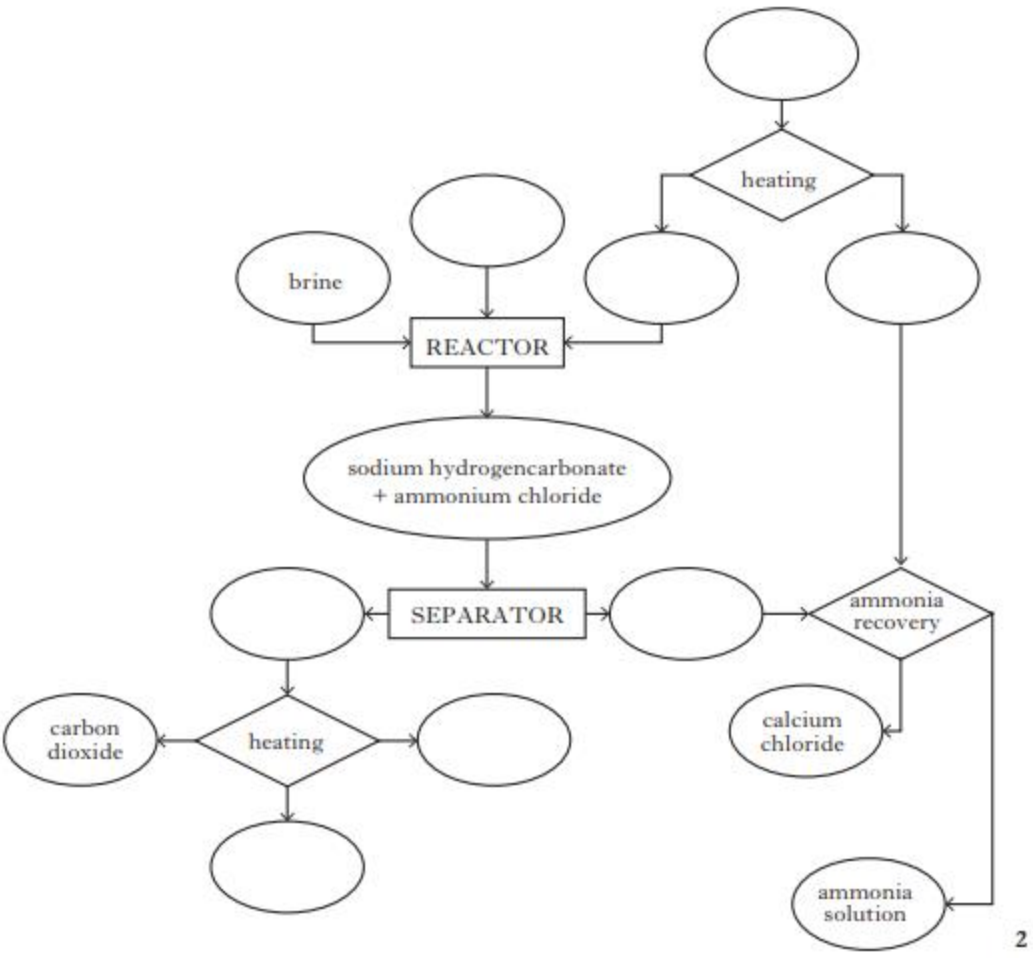
One industrial process used to make sodium carbonate is the Solvay process.

(*a*) The Solvay process involves several different chemical reactions.

It starts with heating calcium carbonate to produce carbon dioxide, which is transferred to a reactor where it reacts with ammonia and brine. The products of the reactor are solid sodium hydrogencarbonate and ammonium chloride which are passed into a separator.

The sodium hydrogencarbonate is heated to decompose it into the product sodium carbonate along with carbon dioxide and water. To recover ammonia the ammonium chloride from the reactor is reacted with calcium oxide produced by heating the calcium carbonate. Calcium chloride is a by-product of the ammonia recovery process.

(i) Using the information above, complete the flow chart by adding the names of the chemicals involved.



2

(a) (continued)

(ii) One way in which the Solvay process is made cost efficient is by recycling ammonia and carbon dioxide.

State another way by which cost efficiency can be achieved in the Solvay process.

1

(b) The reaction that produces the solid sodium hydrogencarbonate involves the following equilibrium:

$$HCO_3^-(aq) + Na^+(aq) \rightleftharpoons NaHCO_3(s)$$

Brine is a concentrated sodium chloride solution.

State why using a concentrated sodium chloride solution encourages production of sodium hydrogencarbonate as a solid.

1

37.

(b) The concentration of sodium hypochlorite in swimming pool water can be determined by redox titration.

Step 1

A 100·0 cm^3 sample from the swimming pool is first reacted with an excess of acidified potassium iodide solution forming iodine.

$$NaOCl(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + NaCl(aq) + H_2O(\ell)$$

Step 2

The iodine formed in step 1 is titrated using a standard solution of sodium thiosulfate, concentration 0·00100 mol l^{-1}. A small volume of starch solution is added towards the endpoint.

$$I_2(aq) + 2Na_2S_2O_3(aq) \rightarrow 2NaI(aq) + Na_2S_4O_6(aq)$$

(i) Describe in detail how the burette should be prepared and set up, ready to begin the titration.

3

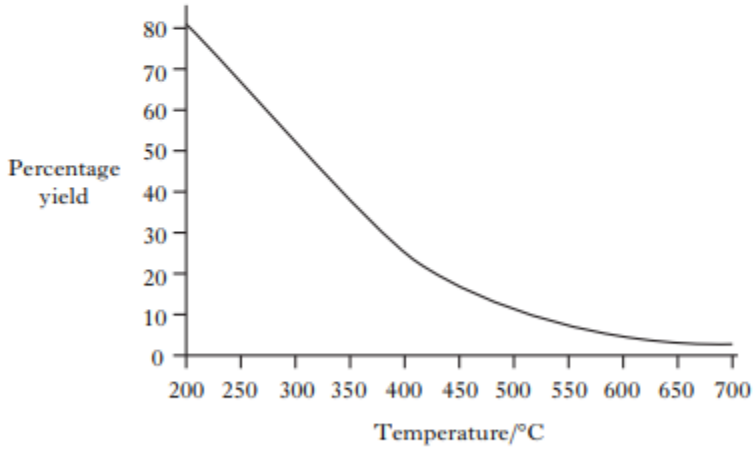
38.

Ammonia is produced in industry by the Haber Process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(*a*) State whether the industrial manufacture of ammonia is likely to be a batch or a continuous process.

(*b*) The graph shows how the percentage yield of ammonia changes with temperature at a pressure of 100 atmospheres.



(i) A student correctly concludes from the graph that the production of ammonia is an exothermic process.

What is the reasoning that leads to this conclusion?

(ii) **Explain clearly** why the industrial manufacture of ammonia is carried out at a pressure greater than 100 atmospheres.

39.

Rivers and drains are carefully monitored to ensure that they remain uncontaminated by potentially harmful substances from nearby industries. Chromate ions, CrO_4^{2-}, are particularly hazardous.

(*a*) When chromate ions dissolve in water the following equilibrium is established.

$$\underset{\text{yellow}}{2CrO_4^{2-}(aq)} + 2H^+(aq) \rightleftharpoons \underset{\text{orange}}{Cr_2O_7^{2-}(aq)} + H_2O(\ell)$$

Explain fully the colour change that would be observed when solid sodium hydroxide is added to the solution.

2

(*b*) The concentration of chromate ions in water can be measured by titrating with a solution of iron(II) sulphate solution.

(i) To prepare the iron(II) sulphate solution used in this titration, iron(II) sulphate crystals were weighed accurately into a dry beaker.

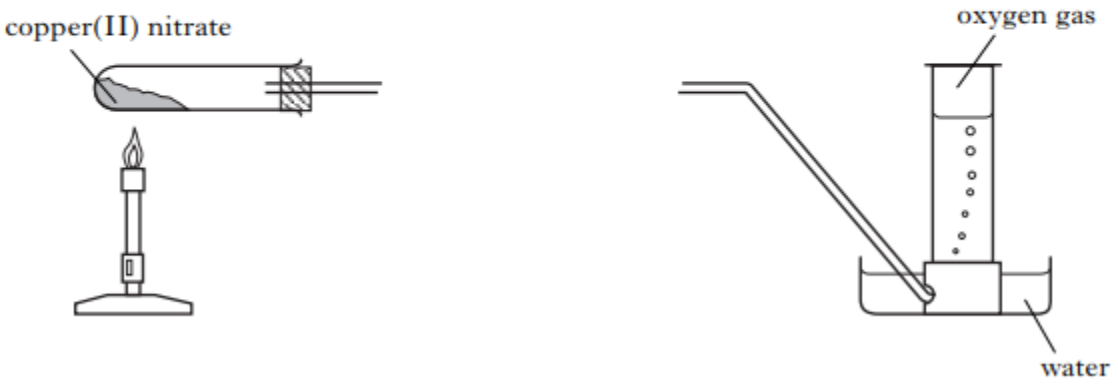
Describe how these crystals should be dissolved and then transferred to a standard flask in order to produce a solution of accurately known concentration.

40.

11. (*b*) (continued)

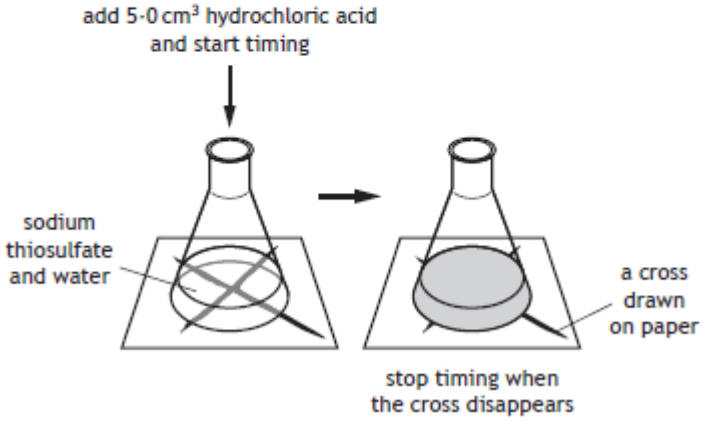
(ii) Nitrogen dioxide has a boiling point of 22 °C.

Complete the diagram to show how nitrogen dioxide can be separated and collected.



41. Sodium thiosulfate, $Na_2S_2O_3$, can be used to investigate the effect of reaction conditions on the rate of reaction.

Sodium thiosulfate solution reacts with hydrochloric acid to form a precipitate of solid sulfur. By placing the reaction mixture in a conical flask over a cross and recording the time taken for the cross to disappear, the effect of changing the reaction conditions can be investigated.



In one set of experiments, the effect of varying the concentration of sodium thiosulfate was investigated.

Experiment	Volume of 0·15 mol l^{-1} $Na_2S_2O_3$ (cm^3)	Volume of water (cm^3)	Rate (s^{-1})
A	50	0	0·0454
B	40		0·0370
C	30		0·0285
D	20		0·0169
E	10	40	0·0063

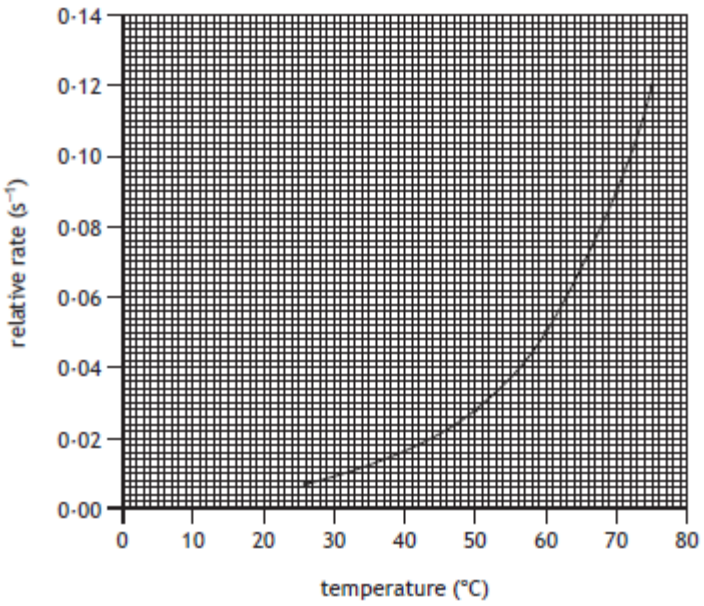
(A) Complete the table to show the volumes of water that would have been used to vary the concentration of sodium thiosulfate. 1

(B) Calculate the time, in seconds, for the cross to disappear in experiment C. 1

41. continued

The reaction can also be used to investigate the effect of changing temperature on the rate of reaction.

The results from an investigation are shown in the graph below.



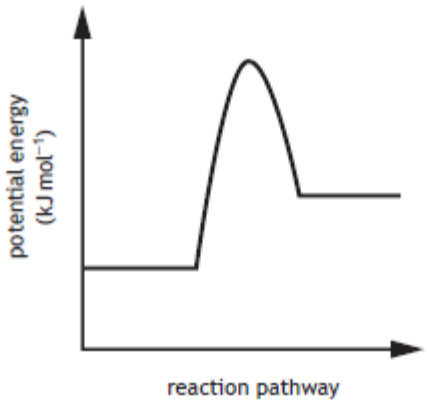
(C) Use the graph to determine the temperature rise, in °C, required to double the rate of the reaction. **1**

(D) Collision theory states that for particles to react they must first collide with each other.

State **two** conditions necessary for the collisions to result in the formation of products. **2**

E Sodium thiosulfate also reacts with iron(III) nitrate.

The potential energy diagram below shows the change in potential energy during the reaction carried out without a catalyst.



(i) Draw an **X** on the potential energy diagram above to show where the activated complex is formed. **1**

(An additional diagram, if required, can be found on *page 41*).

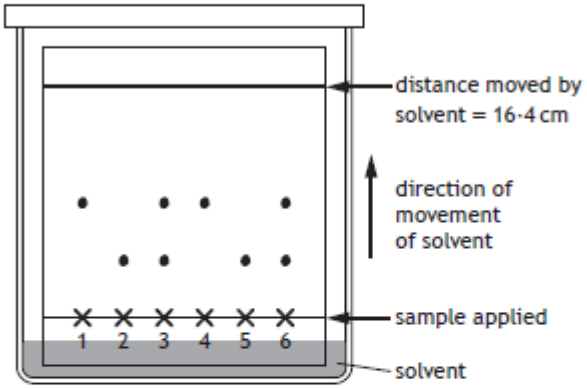
(ii) Cu^{2+} ions catalyse the reaction.

Add a dotted line to the diagram to show the change in potential energy with the catalyst. **1**

(An additional diagram, if required, can be found on *page 41*).

42. The maturing process in cider samples can be monitored using thin layer chromatography.

Samples of lactic acid, malic acid and ciders A, B, C, and D are spotted on a silica plate and the solvent allowed to travel up the plate. The chromatogram obtained is shown below.



Number	Sample applied	Distance moved by spot(s) (cm)
1	lactic acid	8·2
2	malic acid	4·1
3	cider A	4·1, 8·2
4	cider B	8·2
5	cider C	4·1
6	cider D	4·1, 8·2

The retention factor, R_f, for a substance can be a useful method of identifying the substance.

$$R_f = \frac{\text{distance moved by the substance}}{\text{distance moved by the solvent}}$$

(A) Calculate the R_f value of malic acid. 1

(B) The maturing process is complete when all of the malic acid has been converted to lactic acid. The cider is now ready to be bottled.

Use the chromatogram to determine which cider is ready to be bottled. 1

43. The combustion reactions of methane and heptane can be studied in different ways.

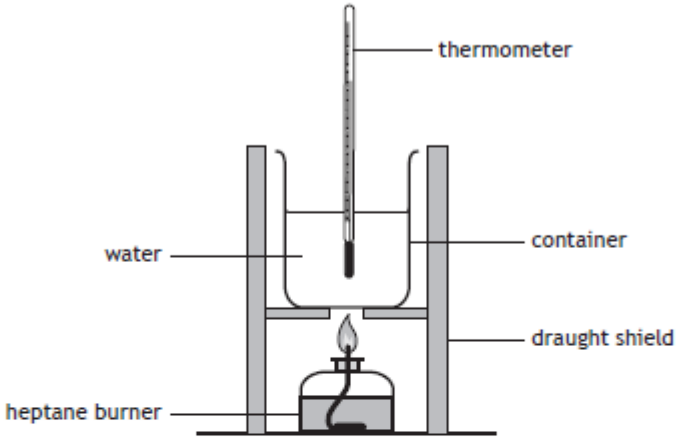
(a) The combustion of methane produces carbon dioxide and water vapour when carried out at temperatures above 100 °C.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

(i) Using bond enthalpies and mean bond enthalpies from the data booklet, calculate the enthalpy change, in kJ mol^{-1}, for this reaction. **2**

(ii) Explain the difference between bond enthalpy and mean bond enthalpy. **1**

(b) The enthalpy of combustion of heptane, C_7H_{16}, can be determined using a calorimeter.



The following results were obtained.

Mass of heptane burned (g)	1·1
Mass of 1 mole of heptane (g)	100·0
Volume of water used (cm^3)	400
Initial temperature of water (°C)	26
Final temperature of water (°C)	49

(i) State the measurements required to calculate the mass of heptane burned in this experiment. **1**

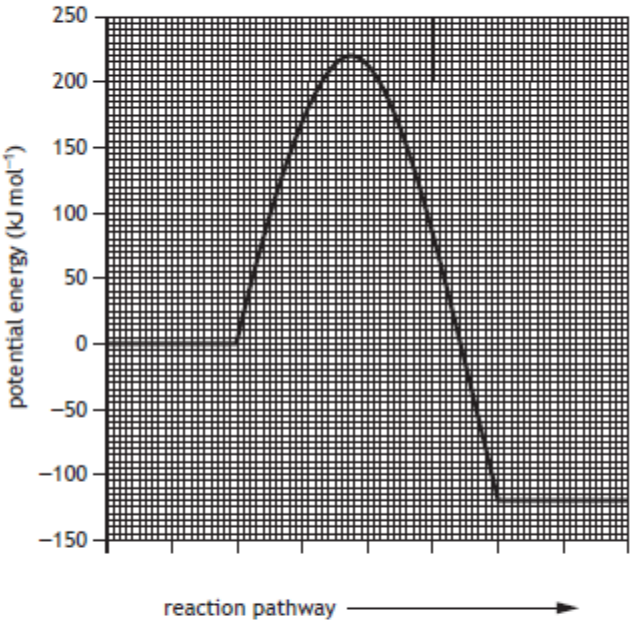
(ii) The theoretical value for the enthalpy of combustion of heptane is significantly higher than the experimental value.

Suggest why the experimental value is different to the theoretical value. 1

44. Chlorine is used in the production of many other chemicals.

(a) Chlorine can be produced by the reaction of hydrogen chloride with air using the Deacon process.

$$4HCl(g) + O_2(g) \rightleftharpoons 2Cl_2(g) + 2H_2O(g)$$

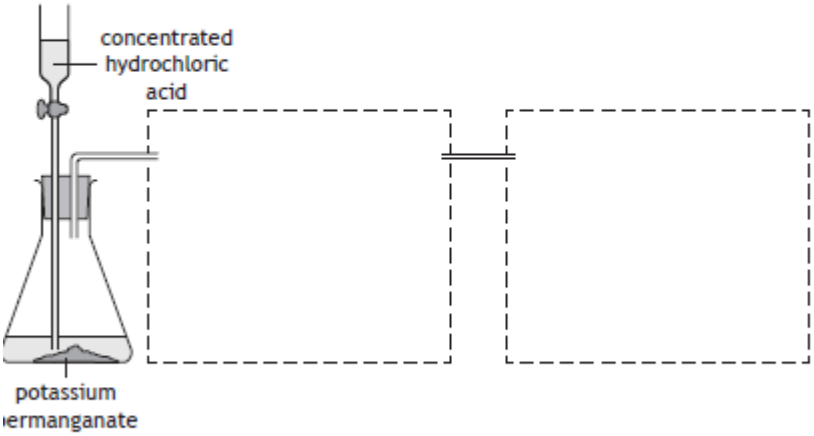


(i) Using the potential energy diagram, determine the activation energy, in kJ mol^{-1}, for the **forward** reaction. 1

(ii) Explain why increasing the temperature in the Deacon process results in less chlorine being produced. 1

44. **(continued)**

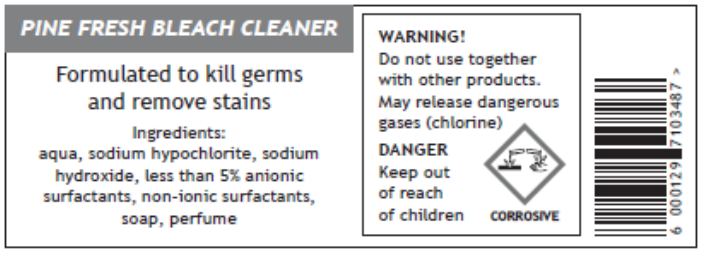
(b) One laboratory method for the preparation of chlorine gas involves adding concentrated hydrochloric acid to potassium permanganate. The chlorine gas produced also contains small amounts of hydrogen chloride gas. To remove the hydrogen chloride gas the gases are bubbled through water. Finally, insoluble chlorine gas is collected.



Complete a labelled diagram to show an apparatus suitable for carrying out this preparation. **2**

(An additional diagram, if required, can be found on *page 41*)

45. Sodium hypochlorite, Na^+OCl^-, is the main active compound in bleach.



Sodium hypochlorite, Na^+OCl^-, is produced by reacting chlorine with sodium hydroxide solution.

$$Cl_2(g) + 2Na^+OH^-(aq) \rightarrow Na^+OCl^-(aq) + Na^+Cl^-(aq) + H_2O(\ell)$$

a) When the chlorine is reacted with sodium hydroxide solution an excess of sodium hydroxide is used.

Suggest why an excess of sodium hydroxide is used. **1**

b) In the bleach cleaner an equilibrium exists.

$$2H^+(aq) + OCl^-(aq) + Cl^-(aq) \rightleftharpoons Cl_2(g) + H_2O(\ell)$$

The label warns that the bleach cleaner should not be used with other products as it may release chlorine gas.

Explain clearly why mixing the bleach with an acid would shift the equilibrium to the right, resulting in the release of chlorine gas from the bleach cleaner. **2**

c) The concentration of hypochlorite, OCl^-, in bleach can be determined by a redox reaction that involves two steps.

Step 1

An excess of acidified potassium iodide is added to the bleach. This converts the iodide ions into iodine.

$$OCl^-(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + Cl^-(aq) + H_2O(\ell)$$

Step 2

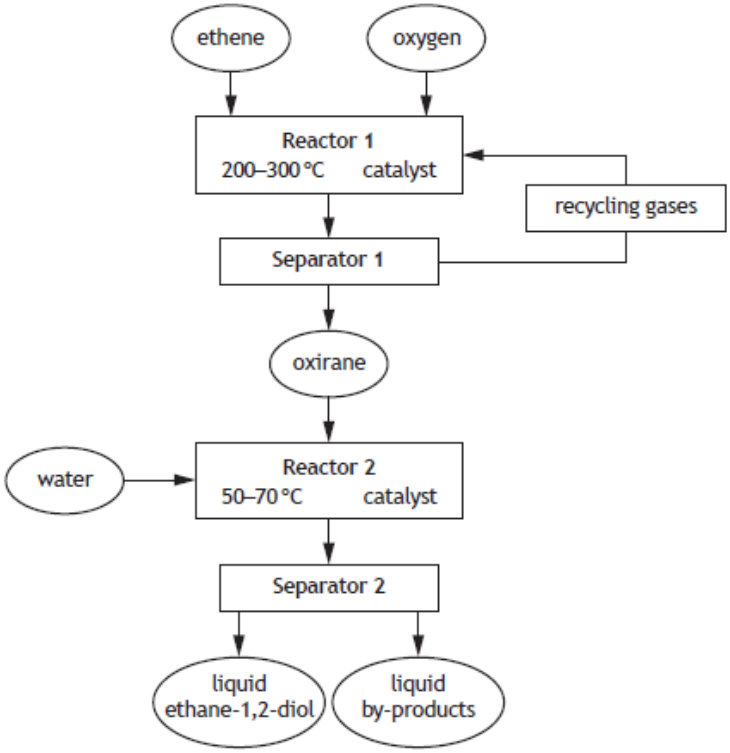
The iodine produced in step 1 is titrated with sodium thiosulfate, $Na_2S_2O_3$.

$$I_2(aq) + 2Na_2S_2O_3(aq) \rightarrow 2NaI(aq) + Na_2S_4O_6(aq)$$

Write the ion-electron equation for the reduction reaction taking place in **Step 1**. **1**

46. Ethane-1,2-diol can be made from ethene.

The flow chart of an industrial process to produce ethane-1,2-diol is shown.



(i) Industrial processes are designed to maximise profit.

Using the flowchart, suggest two ways to maximise profit in this industrial process. **2**

(ii) Name the process used in Separator 2 to separate ethane-1,2-diol from the larger liquid by-products. **1**

47.

Ethane-1,2-diol has been found to be harmful to animals. Treatment for cted animals involves using a 20% ethanol solution.

(i) The 20% ethanol solution is prepared by accurately measuring 20 cm^3 of ethanol and then making up to exactly 100 cm^3 with water.

Describe the procedure which should be used to prepare 100 cm^3 of the 20% ethanol solution. 2

48.

The molar volume (in units of litres per mole) is the same for all gases at the same temperature and pressure.

Using your knowledge of chemistry, suggest how the molar volume of gases could be measured and compared. Any suitable chemicals and apparatus can be used. Some suggested chemicals and apparatus are given below. 3

Chemicals	*Apparatus*
hydrochloric acid	gas syringe
zinc	measuring cylinder
magnesium	delivery tube
calcium	stoppers
water	500 cm^3 flask
sodium carbonate	vacuum pump
calcium carbonate	balance
cylinder of nitrogen	cork ring
cylinder of hydrogen	burette
cylinder of carbon dioxide	filter funnel

49. Iodine is required for a healthy diet. Food grown in certain parts of the world is low in iodine. To prevent iodine deficiency in people's diets, table salt can be 'iodised' by the addition of very small quantities of potassium iodide, KI.

The number of moles of iodide in a sample of salt can be determined by the following procedure.

Step 1

Prepare a standard salt solution by dissolving an accurately weighed sample of iodised salt (50·0 g) in water to give a final volume of 250 cm^3.

Step 2

Transfer 50 cm^3 of salt solution to a conical flask and add excess bromine solution to convert the iodide ions to iodine.

Step 3

Titrate the iodine (I_2) released with sodium thiosulfate solution ($Na_2S_2O_3$).

(a) Describe a procedure to accurately weigh out a 50·0 g sample of iodised table salt. 1

(b) The overall equation for the reaction of bromine solution with iodide ions is shown.

$$2I^-(aq) + Br_2(aq) \rightarrow I_2(aq) + 2Br^-(aq)$$

Write the ion-electron equation for the oxidation reaction. 1

50. Reactions involving iodine are commonly used to investigate rates of reaction.

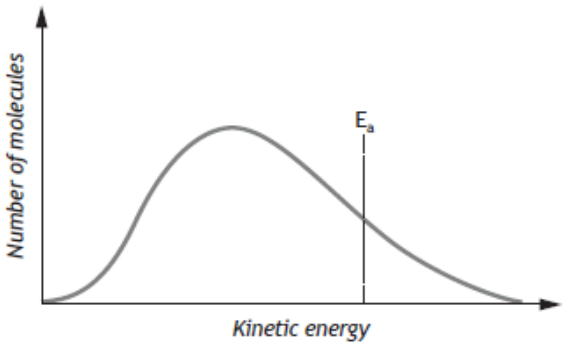
(a) One reaction involves hydrogen and iodine reacting together to form hydrogen iodide.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

(i) This reaction is thought to occur by initially breaking bonds in one of the reactants.

Explain, using bond enthalpies, which bond is more likely to break first during this reaction. 1

(ii) The graph shows the distribution of kinetic energies of reactant molecules in the gas mixture at 300 °C.



Add a second curve to the graph to show the distribution of kinetic energies at 400 °C. 1

(a) (continued)

(iii) The reaction to produce hydrogen iodide is exothermic.

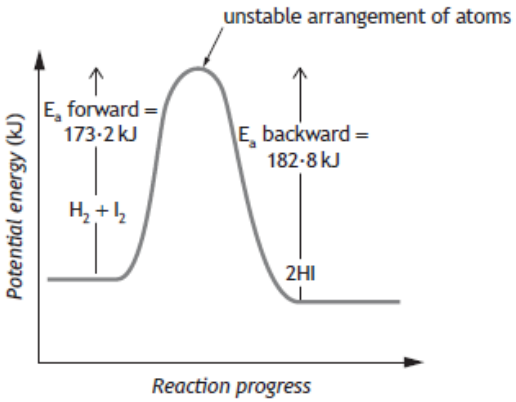
$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

(A) State the effect of increasing temperature on the position of equilibrium. 1

(B) State why changing the pressure has no effect on this equilibrium reaction. 1

(a) (continued)

(iv) The potential energy diagram for the reaction between hydrogen and iodine is shown.



(A) State the term for the unstable arrangement of atoms. 1

(B) Platinum can be used as a catalyst for this reaction.

State the effect that platinum would have on the activation energy for the reaction. 1

50. continued

(b) The reaction between iodide ions, $I^-(aq)$, and persulfate ions, $S_2O_8^{2-}(aq)$, is used to investigate the effect of changing concentration on rate of reaction. The relative rate of the reaction is determined by mixing the reactants in a beaker and recording the time taken for the mixture to change colour.

The results of the investigation are shown in the table.

Experiment	*Concentration of $I^-(aq)$* (mol l^{-1})	*Concentration of $S_2O_8^{2-}(aq)$* (mol l^{-1})	*Time* (s)	*Relative rate* (s^{-1})
1	0·04	0·05	241	0·00415
2	0·06	0·05	180	0·00556
3	0·08	0·05		0·00819
4	0·1	0·05	103	0·00971

(i) The instructions state that a dry beaker must be used for each experiment.

Suggest a reason why the beaker should be dry. 1

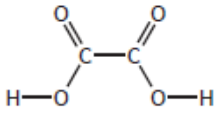
(ii) Calculate the time, in seconds, for the reaction in experiment 3. 1

(iii) Explain why decreasing the concentration of iodide ions lowers the reaction rate. 1

51.

The leaves of the rhubarb plant are considered poisonous because they contain high levels of oxalic acid.

Oxalic acid is a white, water-soluble solid. It is a dicarboxylic acid that has the structural formula shown.



Oxalic acid reacts with bases to form salts.

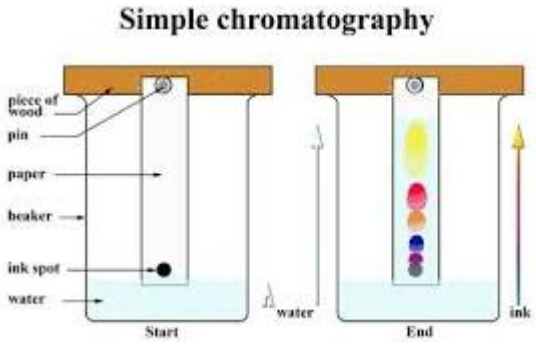
It can also be oxidised by strong oxidising agents to form carbon dioxide gas. The oxidation equation for oxalic acid is shown.

$$H_2C_2O_4 \rightarrow 2CO_2 + 2e^- + 2H^+$$

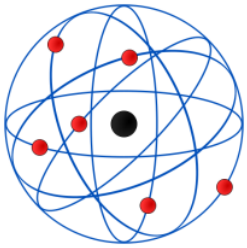
Using your knowledge of chemistry, comment on how the mass of oxalic acid in a rhubarb leaf could be determined. 3

Higher Chemistry

Unit 3 Past Paper Answers

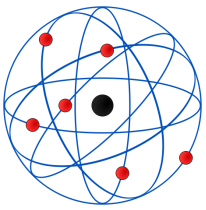


Section 1 Answers



1	D	11	C	21	D	31	C	41	D	51	A	61	B
2	D	12	D	22	D	32	A	42	B	52	C	62	B
3	B	13	B	23	D	33	A	43	D	53	D	63	C
4	D	14	B	24	A	34	C	44	D	54	C	64	B
5	B	15	B	25	A	35	D	45	B	55	A	65	C
6	D	16	A	26	D	36	D	46	C	56	B	66	D
7	C	17	A	27	C	37	C	47	B	57	A	67	B
8	A	18	A	28	B	38	A	48	B	58	D		
9	A	19	D	29	C	39	B	49	C	59	D		
10	D	20	B	30	D	40	C	50	B	60	C		

Section 2 Answers



1.

(d)	(i)	Diagram shows a workable method for the passing of chlorine gas over heated aluminium. Aluminium must be labelled and there must be an indication of heat. Heated aluminium accepted. **(1)** Diagram allows aluminium chloride to be collected **in a flask** as a solid and chlorine gas to escape. **(1)**	**2**	Labels must be correct.
	(ii)	To provide (initial) activation energy/(sufficient) energy to form activated (activation) complex.	**1**	Accept activation energy is high.

2.

(a)	(i)	**1 mark each** for any two of the following points. • recycle (waste) gases • use catalyst • low/reduce energy requirements • reactors are run at low temperatures/the temperatures in the reactors is lowered • inexpensive feedstocks • selling/using by-products	**2**	Recycle by-products is not accepted.
	(ii)	(fractional) distillation	**1**	Evaporation followed by condensation or a correct description of distillation are accepted.

3.

(d)	(i)	Pipette (used to measure 20cm^3 of ethanol.) **(1)** Statement of use of **volumetric/ standard** flask to make up to / fill to the mark/ to 100cm^3. **(1)**	**2**	Not acceptable to use burette.

4.

(a)		Correct description of weighing by difference. **OR** Correct description of use of the Tare function.	**1**	'weighing by difference' on its own is accepted.

5.	(a)	(i)	Diagram shows a workable method of bubbling through concentrated sulfuric acid. 1 mark Diagram for appropriate gas collection method i.e. using a gas syringe or upward displacement of air. 1 mark	**2**	

6.

(a)	(i)	I-I bond is weaker/has a lower bond enthalpy value (so will break more easily) **OR** I_2 (151 kJ mol^{-1}) is less than H_2 (436 kJ mol^{-1}), (so will break more easily).	1	Iodine on its own is not acceptable.
	(ii)	Peak of curve should be further to the right and no higher than the original line.	1	
	(iii) (A)	Equilibrium will shift to the reactant side/left (hand side).	1	
	(iii) (B)	There are the same/equal volume/ number of moles/molecules (of gases) on each side (of the equation). **OR** Pressures of reactants and products are equal.	1	Ratios on their own, without an explanation, are not acceptable eg 1:1 or 2:2
(iv) (A)	Activated complex		1	Accept activation complex or transition state.
(iv) (B)	-9·6 (kJ) If candidate has calculated from graph values **OR** -9 (kJ) If candidate has calculated using bond enthalpies Answer must include the negative sign		1	No units required. No mark can be awarded for the correct answer if wrong unit is given. (wrong units would only be penalised once in any paper) kJ mol^{-1} is acceptable in place of kJ
(iv) (C)	Decrease/lower it		1	

7.	(a)		Rinse beaker and transfer the rinsings/washings to the flask	**1**	
	(b)	(i)	The reaction is self-indicating. **OR** Potassium permanganate can act as its own indicator. **OR** Reaction changes colour.	**1**	
		(ii)	To provide H^+ ions for the reaction.	**1**	
		(iii) (A)	**1 mark** for any of the following • first titre is a rough (or approximate) result/practice • first titre is not accurate/not reliable/rogue • first titre is too far away from the others • you take average of concordant/close results	**1**	
	(iii) (C)		A solution of accurately/exactly/ precisely known concentration	**1**	
	(iii) (D)		Pipette	**1**	Not: Burette Accept graduated pipette.

8.

(a)	(i)	40·23/40·2/40 (%)	**1**	
	(ii)	geranyl acetate/peak 5	**1**	

9.

(a)		The number of **successful** collisions will increase/There will be a greater chance of successful collisions **(1 mark)** **OR** More reactant particles will have energy equal to or greater than the activation energy. **(1 mark)**	**1**	Also acceptable More particles have sufficient/enough energy to react.
(b)	(i)	1 mark for drawing suitable experiment that will work **and** for indicating how **volume** will be measured eg collecting in a gas syringe or downward displacement of water from a measuring cylinder or similar.	**1**	Accept a recognisable/labelled gas syringe, as long as graduations are shown. Graduations must be shown if a measuring cylinder is used. Mark not awarded if delivery tube passes through the side of a measuring cylinder.

10.	(d)	(i)	The peptide molecule: must have contained an amino acid that is repeated in the sequence **OR**	**1**	
			contained only four different amino		

11.

(a)	(i)	<table><tr><th></th><th>Temperature (High/Low)</th><th>Pressure (High/Low)</th></tr><tr><td>Step 1</td><td>High</td><td>Low</td></tr><tr><td>Step 2</td><td>Low</td><td>High</td></tr></table>	**2**	Temperature and pressure are dealt with separately as two single marks.
	(ii)	The proportion of the total mass of all starting materials successfully converted into the desired product is 100% **OR** All the atoms in the reactants are converted into the product you want./Mass of **product** is equal to mass of reactants **OR** No by-products/no waste products/ only one product is formed.	**1**	

12.

(a)	(i)	A drawing that shows a flask with a long narrow neck and a single gradation mark which goes completely across, or is labelled, on the narrow neck.	1	
	(ii)	Accurate method for volume measurement eg uses pipette **(1 mark)** Describes weighing by difference or using a tared balance. **(1 mark)**	2	Burette would be accepted. Syringe not accepted for measuring volume accurately.

13.

(b)	**(i)**	Second line displaced to left of original. Peak of curve should be to the left of the original peak	1	
	(ii)	A vertical line drawn at a lower kinetic energy that the original E_a shown on graph	1	

14.

(a)	**(i)**	Workable apparatus for passing steam **through** strawberry gum leaves **(1)** Workable apparatus for condensing the steam and essential oil **(1)**	2	Treat both marks separately "Through" not "over" A closed system would not allow candidates to gain mark for condensation.
	(ii)	(Fractional) distillation or chromatography	1	

15.

(a)		Any one of the common compounds correctly identified ie citronellol / geraniol / anisyl alcohol	**1**	
(b)		The concentration / volume of compounds (that are common to both/present in the counterfeit) is different are present in lower concentration in the counterfeit	**1**	Answer must relate to the perfume and not to the chromatogram.
(c)	**(i)**	Inert / will not react with the molecules (being carried through the column)	**1**	
	(ii)	Size (mass) of molecules / temperature of column.	**1**	

16.

(a)		Calcium carbonate / carbon dioxide / ammonia / calcium oxide **all** correctly identified in flow diagram **(1)** Ammonium chloride / sodium hydrogen carbonate / sodium carbonate / water - all correctly identified in flow diagram **(1)**	**2**	
(b)		(Adding brine) increases sodium ion concentration hence equilibrium shifts to right **(1)** Rate of forward reaction is increased (by addition of brine) **(1)**	**2**	

17.

(a)	**(i)**	24 hours allows time for all of the zinc to react **(1)** No stopper allows hydrogen gas to escape from the flask. **(1)**	**2**	
	(ii)	Zinc ions / impurities / metal ions / salts may be present in tap water	**1**	
(b)	**(i)**	pipette	**1**	Do not accept measuring cylinder or syringe or burette

18.

(a)	**(i)**	3 points **1 mark** for rinsing the burette - rinse the burette with the **thiosulfate / required solution** / with the solution to be put in it. **2 marks (1 mark each)** for any 2 of the following points fill burette above the scale with thiosulfate solution filter funnel used should be removed tap opened / some solution drained to ensure no air bubbles (thiosulfate) solution run into scale reading should be made from bottom of meniscus	**3**	

19.

(a)	(i)	A solution of exactly/accurately/precisely known concentration	**1**	

(iii)		Dissolve (sample) in a small/minimum volume of (deionised) water **(1)** Transfer with rinsings **(1)** Make up to the mark in a **volumetric/standard** flask **(1)**	**3**	

(iv)		(Tap water) might contain fluoride ions. OR (Tap water) might contain species that interfere with the reaction. OR (Tap water) might be coloured.	1	

(b)	(i)		Pipette	1	

20.

(c)	(i)		Gas-tight reaction vessel fitted with delivery tube **(1)** Method for collecting and measuring the volume of gas produced **(1)** Hydrogen peroxide, bleach and oxygen labelled in correct position **(1)**	3	Award a maximum of 2 marks if the diagram of apparatus shown would not work in practice.

21.

(a)	(i)		Purple to colourless	1	

(b)	(i)		The peak of the curve should be to the left and higher than the original peak.	1	
	(ii)		A vertical line should have been drawn at a lower kinetic energy than the original Ea shown on graph.	1	
(c)			Incorrect orientation/geometry OR Activated complex breaks up to reform the reactants	1	

22.

(ii) for curve starting and finishing at R and P but with maximum below the existing maximum – 1 mark	

23.

(*a*) $2NaOH + Cl_2 \rightarrow NaClO + NaCl + H_2O$ – 2 marks Correct formulae for all but one substance, whether balanced or not – 1 mark	
(*b*) NaOH results in decrease in H+ ion concentration – 1 mark Position of equilibrium moves to the right and ClO^- increases – 1 mark	Statement that hypochlorite bleach is made by reacting sodium hydroxide with chlorine – 0 marks (This is in the question.)

24.

(ii) mention of transfer of rinsings – 1 mark making up to the mark of standard/volumetric flask – 1mark	
(iii) tap water could contain nitrites – 1 mark Or Distilled water will not contain nitrites – 1 mark Mention of nitrites required for this mark	Tap water is less clean than distilled (or similar) – 0 marks
(iv) Mass required to make 250 cm^3 of 0·05 mg l^{-1} solution is too small to weigh accurately – 1 mark	

25.

(*a*) during evaporation, smaller molecules lost – 1 mark Evaporated sample has peaks with shorter RT missing – 1 mark	
(*b*) both "paint thinner" and "lemon fresh furniture spray" – 1 mark	

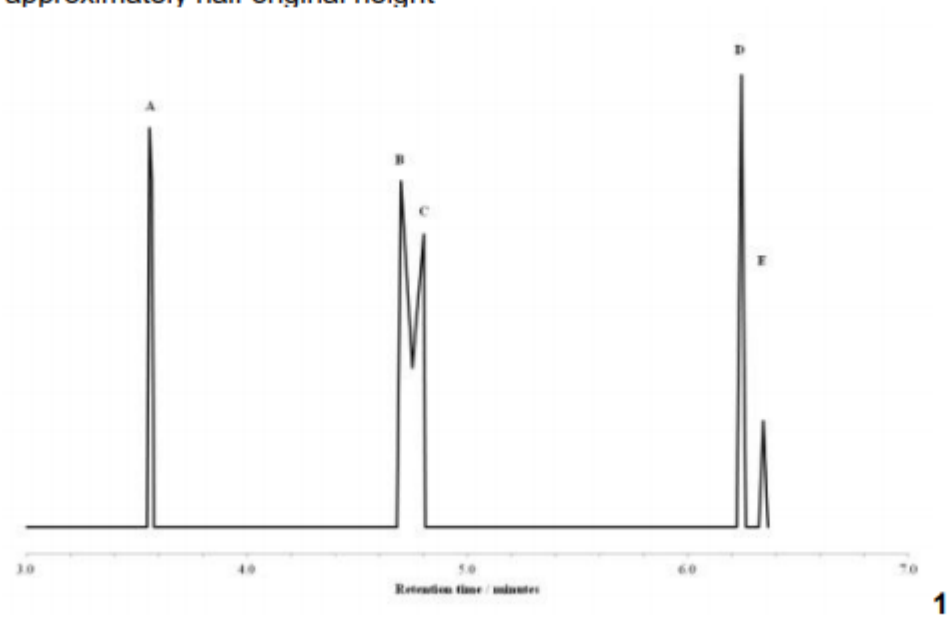
26.

(c)	**(i)** pipette or burette	**1**	Measuring cylinder syringe
	(ii) a solution of exactly/accurately known concentration or exact concentration or precise concentration	**1**	

27.

(b)	**(i)** 69 – 70 (mg l^{-1} – no units required. Ignore incorrect units)	**1**	
	(ii) Sample of Y should be diluted or less of sample Y should be used or smaller sample of Y	**1**	

28.

d	**i**	Benzocaine is a smaller/Tetracaine is bigger **(1)** **or** weaker London Dispersion Forces with Benzocaine **(1)** **or** weaker Van der Waal's forces for Benzocaine **(1)** **or** Benzocaine has lower b.pt **(1)** **or** Benzocaine more soluble/attracted in/ to mobile phase **(1)** **or** Benzocaine less strongly attracted to stationary phase **(1)** **or** Benzocaine is more polar **(1)**	**1**	Benzocaine takes less time to travel through the apparatus
d	**ii**	The peaks for lidocaine and caffeine overlap **or** Candidate wording for idea of masking	**1**	The retention times are similar
d	**iii**	Peak for tetracaine at correct RT with approximately half original height  	**1**	

29.

a	**i**	For successful generation of gas; must have iron sulfide, hydrochloric acid and appropriate glassware to transfer the gas to the gas collection/ measurement apparatus without loss of gas **(1)** For the successful collection and measurement of the gas; must have a syringe or collect the gas in a measuring cylinder over a non-aqueous liquid **(1)**	**2**	

30.

b			**1**	

temperature	decrease/keep the same/increase
pressure	decrease/keep the same/increase

31.

a		Diagram completed to show viable method of drying gas using calcium oxide.	**1**	

32.

a	**ii**	Pipette rinsed with fruit juice and burette with iodine solution **Both for 1 mark** Conical flask rinsed with water**1 mark**	**2**	
a	**iii**	Improve reliability (accept improved accuracy) / allow an average value to be calculated.	**1**	

33.

b		Collision must occur with sufficient or required or activation energy **1 mark** Collision must occur with suitable geometry **1 mark**	**2**	With correct speed With high energy

34.

b	**i**	Mention of transferring of rinsings. **1 mark** Mention of making solution up to the mark of the standard/ volumetric flask **1 mark**	**2**	

35.

a	**i**	Workable apparatus for passing the steam **through** strawberry gum leaves **(1)** Workable apparatus for condensing the steam and essential oil **(1)**	**2**	Both marks should be treated separately "Through" not "over" A closed system would not allow candidates to gain mark for condensation.
a	**ii**	(Fractional) distillation **or** chromatography	**1**	

36.

a	**i**	Calcium carbonate/carbon dioxide/ ammonia/ calcium oxide **all** correctly identified in flow diagram **(1)** **and** ammonium chloride/sodium hydrogen carbonate/ sodium carbonate/water **all** correctly identified in flow diagram **(1)**	**2**	
a	**ii**	Calcium chloride / by-products can be sold	**1**	
b		(Adding brine) increases sodium ion concentration hence equilibrium shifts to right	**1**	

37.

b	**i**	3 points (**1 mark each**) from – **1 mark** for preparation of burette – rinse the burette with the thiosulfate solution rinse the burette with the solution to be put in it / with the solution **2 marks (1 mark each)** for any 2 of the following points • fill burette above the scale with thiosulfate solution • filter funnel used should be removed • tap opened/some solution drained to ensure no air bubbles • (thiosulfate) solution run into scale • reading should be made from bottom of meniscus	**3**	

38.

Mark Scheme			Worth ½	Worth 0
(a)	continuous	**1**		
(b)	**(i)** yield decreases at high temperature **(½)** idea that equilibrium moves to the left (or to reactant side) at high temperature **(½) or** corresponding explanation based on higher yield at lower temperatures	**1**	backward reaction removes heat	
	(ii) idea that the formation of ammonia decreases the number of molecules (or reduces the pressure) **(1)** idea that high pressure causes the equilibrium position to move to right (or product side) **or** high pressure favours the reaction that reduces the pressure **(1)**	**2**		

(no ½ marks in new Higher)

39.

(a) On addition of NaOH(s)… • OH^- react with H^+ (½) • concentration of H^+ decreases (½) • equilibrium position to shift to the left (½) • CrO_4^{2-} ion concentration increases (½) [Any three from the list above for up to 1½] Final half mark for solution becomes more yellow/ less orange(½)	**2**		
(b) **(i)** Looking for two key points • mention of <u>washings/rinsings</u> (1) • make the (standard) flask up to the mark with water (1)/add water until desired volume reached	**2**		

40.

(ii) Diagram showing any method of condensing the nitrogen dioxide **(½)** and workable way of collection **(½)** eg U tube in ice	**1**		

41.

A

		A	<table><tr><th>Experiment</th><th>Volume of water (cm^3)</th></tr><tr><td>A</td><td>0</td></tr><tr><td>B</td><td>10</td></tr><tr><td>C</td><td>20</td></tr><tr><td>D</td><td>30</td></tr><tr><td>E</td><td>40</td></tr></table>All entries correct 1 Mark.	1	

B

		B	35/35·1/35·09 (seconds or s)	1	No units required. No mark can be awarded for correct answer if wrong unit is given (where no unit required, wrong units would only be penalised once in any paper). sec or secs not accepted.

C

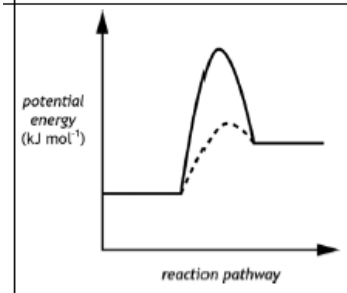
12 +/- 1 (°C)	1	Award 0 marks if 10°C given. No units required. No mark can be awarded for correct answer if wrong	
(Particles must have) sufficient or enough energy (to react). OR (Particles must have) energy equal to or greater than the activation energy or E_A. OR (Particles must have) minimum/ enough energy to form an activated complex. **(1)** (Collision must occur with) suitable/correct/geometry/ orientation **(1)**	2	Do not accept 'with correct speed', 'with high energy' or "sufficient activation energy". "They"/"reactants" accepted for particles.	be

D

E i)

X shown at peak of curve	1	Must be centred and within the y-axis. Clear indication of the correct position of the activated complex is accepted.

ii)

	1	The peak drawn shows a lower activation energy. Line drawn does not need to be a dotted/dashed line. The line drawn by the candidate must start and finish at the same potential energies as on the original diagram.

42. - 43.

(a)	(i)	-694 (kJ mol^{-1}) Bond breaking (4 x 412) + (2 x 498) = 2644 Bond forming [(2 x 743) + (4 x 463)] = -3338 A single mark is available if either of the following operations is correctly executed Either The four relevant values for bond enthalpies of the C-H, O=O, C=O, and O-H (or multiples thereof) are retrieved from the data booklet (412, 498, 743, 463 - ignore signs). OR If only three correct values are retrieved, the candidate recognises that bond breaking is endothermic and bond forming is exothermic and have correctly manipulated the bond enthalpies and multiples that they have used with working shown.	2	+694 would qualify for 1 mark No units required. Only 1 mark can be awarded for the correct answer if wrong unit is given. (wrong units would only be penalised once in any paper) kJ is acceptable in place of kJ mol^{-1} (KJ or Kj or KJ mol^{-1} or Kj mol^{-1} accepted). If less than three bond enthalpies are retrieved then no mark can be awarded.
	(ii)	Mean bond enthalpy must refer to an average energy and to a number of compounds and bond enthalpy must relate to one compound/diatomic molecule.	1	

(b)	(i)	(Record the) mass/weight of the burner before and after (heating the water)	1	

(ii)	1 mark for any of the following • Loss of heat/energy to the surroundings • Incomplete combustion (of heptane/alkane) • Loss (of heptane/alkane) by evaporation • No lid on container • No stirring • Absorption of heat glass/beaker or copper can	1	'Not using a bomb calorimeter' on its own would not be awarded a mark. "Loss of heat" on its own is not sufficient but would not be cancelling.

44.

(a)	(i)	(+) 220 (+/- 2) (kJ mol^{-1})	1	No units required. No mark can be awarded for correct answer if wrong unit is given (where no unit required, wrong units would only be penalised once in any paper). kJ is acceptable in place of kJ mol^{-1} (KJ or Kj or KJ mol^{-1} or Kj mol^{-1} accepted).
	(ii)	(Increasing temperature) favours the endothermic/reverse reaction OR The (forward) reaction is exothermic. OR The reverse reaction is endothermic.	1	

(b)		Diagram shows a workable method for removal of HCl(g) allowing transfer of chlorine gas. Water/H_2O must be labelled. (1) Diagram shows a workable method of collecting a gas (eg a gas syringe). (1)	2	Treat each mark separately. Mark not awarded if delivery tube passes through the wall of measuring cylinder/test tube A closed system would not be a suitable method for collecting a gas.

45.

a)	**1 mark** for any of the following • To ensure all chlorine is used up/to prevent chlorine being released • NaOH is the cheaper/less expensive reactant • To ensure that the bleach cleaner contains sodium hydroxide • Excess NaOH would neutralise any acid added to cleaner • Excess NaOH helps break up oil/grease	1	
b)	(Adding acid) adds/increases H^+ (ions) (1) Rate of forward reaction is increased/ speeds up (by addition of acid) (1)	2	
c)	$OCl^-_{(aq)} + 2H^+_{(aq)} + 2e^- \rightarrow Cl^-_{(aq)} + H_2O_{(l)}$	1	State symbols not required but any given must be correct. Charge on electron not required.

46 i)

(i)	**1 mark each** for any two of the following points. • recycle (waste) gases • use catalyst • low/reduce energy requirements • reactors are run at low temperatures/the temperatures in the reactors is lowered • inexpensive feedstocks • selling/using by-products	2	Recycle by-products is not accepted.
(ii)	(fractional) distillation	1	Evaporation followed by condensation or a correct description of distillation are accepted.

47.

Pipette (used to measure $20cm^3$ of ethanol.) (1) Statement of use of **volumetric/ standard** flask to make up to / fill to the mark/ to $100cm^3$. (1)	2	Not acceptable to use burette.

48.

This is an open ended question **1 mark:** The student has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. The candidate has made some statement(s) which is/are relevant to the situation, showing that at least a little of the chemistry within the problem is understood. **2 marks:** The student has demonstrated, at an appropriate level, a reasonable understanding of the chemistry involved. The student makes some statement(s) which is/are relevant to the situation, showing that the problem is understood. **3 marks:** The maximum available mark would be awarded to a student who has demonstrated, at an appropriate level, a good understanding of the chemistry involved. The student shows a good comprehension of the chemistry of the situation and has provided a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the problem. This does not mean the answer has to be what might be termed an 'excellent' answer or a 'complete' one.	3	Zero marks should be awarded if: The student has demonstrated, at an appropriate level, no understanding, of the chemistry involved. There is no evidence that the student has recognised the area of chemistry involved or has given any statement of a relevant chemistry principle. This mark would also be given when the student merely restates the chemistry given in the question.

49.

(a)		Correct description of weighing by difference. **OR** Correct description of use of the Tare function.	1	'weighing by difference' on its own is accepted.
(b)		$2I^-(aq) \rightarrow I_2(aq) + 2e^-$ **OR** $2I^-(aq) \rightarrow I_2(s) + 2e^-$	1	State symbols not required. Negative sign on electron not required.

50.

(a)	(i)	I-I bond is weaker/has a lower bond enthalpy value (so will break more easily) OR I_2 (151 kJ mol^{-1}) is less than H_2 (436 kJ mol^{-1}), (so will break more easily).	1	Iodine on its own is not acceptable.
	(ii)	Peak of curve should be further to the right and no higher than the original line.	1	
	(iii) (A)	Equilibrium will shift to the reactant side/left (hand side).	1	
	(iii) (B)	There are the same/equal volume/ number of moles/molecules (of gases) on each side (of the equation). OR Pressures of reactants and products are equal.	1	Ratios on their own, without an explanation, are not acceptable eg 1:1 or 2:2
	(iv) (A)	Activated complex	1	Accept activation complex or transition state.
(iv) B		Decrease/lower it	1	

50.

(b)	(i)	To keep the concentration (of the reactants) constant. OR Adding water will change/affect/ dilute/decrease the concentration (of the reactants) OR To keep the total volume constant.	1	
	(ii)	122·1 (accept 122) (s)	1	No units required. No mark can be awarded for the correct answer if wrong unit is given. (wrong units would only be penalised once in any paper)
	(iii)	The number of (successful) collisions will decrease. OR Less chance of (successful) collisions OR The frequency of (successful) collisions will decrease.	1	Any mention of time of collisions is unacceptable.

51.

This is an open ended question **1 mark:** The student has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. The candidate has made some statement(s) at which is/are relevant to the situation, showing that at least a little of the chemistry within the problem is understood. **2 marks:** The student has demonstrated, at an appropriate level, a reasonable understanding of the chemistry involved. The student makes some statement(s) which is/are relevant to the situation, showing that the problem is understood. **3 marks:** The maximum available mark would be awarded to a student who has demonstrated, at an appropriate level, a good understanding of the chemistry involved. The student shows a good comprehension of the chemistry of the situation and has provided a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the problem. This does not mean the answer has to be what might be termed an 'excellent' answer or a 'complete' one.	3	Zero marks should be awarded if: The student has demonstrated, at an appropriate level, no understanding, of the chemistry involved. There is no evidence that the student has recognised the area of chemistry involved or has given any statement of a relevant chemistry principle. This mark would also be given when the student merely restates the chemistry given in the question.