X012/701

NATIONAL QUALIFICATIONS 2004

WEDNESDAY, 2 JUNE
9.00 AM – 11.30 AM

CHEMISTRY
ADVANCED HIGHER

Reference may be made to the Chemistry Higher and Advanced Higher Data Booklet (1999 edition).

SECTION A

Check that the answer sheet provided is for Chemistry Advanced Higher (Section A).

Fill in the details required on the answer sheet.

Rough working, if required, should be done only on this question paper, or on the rough working sheet provided—**not** on the answer sheet.

Instructions for completion of **SECTION A** are given on page two.

SECTION B

All questions should be attempted.

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SECTION A

In questions 1 to 40 of this part of the paper, an answer is given by indicating the choice A, B, C or D by a stroke made in INK in the appropriate place in the answer sheet—see the sample question below.

For each question there is only ONE correct answer.

This part of the paper is worth 40 marks.

SAMPLE QUESTION

To show that the ink in a ball-pen consists of a mixture of dyes, the method of separation would be

A fractional distillation

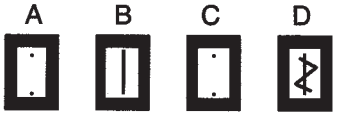
B chromatography

C fractional crystallisation

D filtration.

The correct answer is B—chromatography. A **heavy** vertical line should be drawn joining the two dots in the appropriate box in the column headed **B** as shown **in the example on the answer sheet.**

If, after you have recorded your answer, you decide that you have made an error and wish to make a change, you should cancel the original answer and put a vertical stroke in the box you now consider to be correct. Thus, if you want to change an answer **D** to an answer **B**, your answer sheet would look like this:



If you want to change back to an answer which has already been scored out, you should **enter a tick (✓)** to the RIGHT of the box of your choice, thus:

1. According to the aufbau principle, electrons fill orbitals in the order

   A 1s 2s 2p 3s 3p 4s 4p 3d

   B 1s 2s 2p 3s 3d 3p 4s 4p

   C 1s 2s 2p 3s 3p 3d 4s 4p

   D 1s 2s 2p 3s 3p 4s 3d 4p.

2. A Lewis base may be regarded as a substance which is capable of donating an unshared pair of electrons to form a covalent bond.

   Which of the following could act as a Lewis base?

   A BCl_3

   B NH_4^+

   C PH_3

   D Co^{3+}

3. Which of the following statements referring to the structures of sodium chloride and caesium chloride is correct?

   A There are eight chloride ions surrounding each sodium ion.

   B There are eight chloride ions surrounding each caesium ion.

   C The chloride ions are arranged tetrahedrally round the sodium ions.

   D The chloride ions are arranged tetrahedrally round the caesium ions.

4. Which of the following is the best term to describe aluminum oxide?

   A Basic

   B Acidic

   C Neutral

   D Amphoteric

5. Which of the following compounds contains hydride ions?

   A NH_3

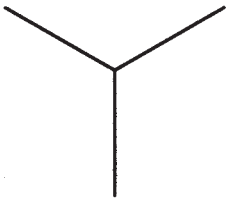
   B HCl

   C H_2S

   D CaH_2

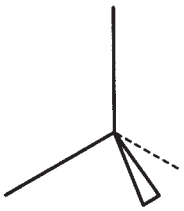
Questions 6 and **7** refer to the following diagrams which indicate different arrangements of **electron pairs**.

A



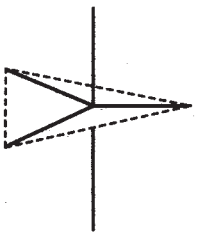
trigonal planar

B



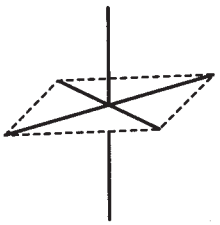
tetrahedral

C



trigonal bipyramidal

D



octahedral

Which arrangement of electron pairs will be found in the following molecules?

6. NF_3

7. ClF_3

[Turn over

8. The number of unpaired electrons in a gaseous Ni^{2+} ion is

A 0

B 2

C 4

D 6.

9. Which of the following ions is **least** likely to be coloured?

A $Ti(H_2O)_6^{3+}$

B $Cr(NH_3)_6^{3+}$

C $Ni(H_2O)_6^{2+}$

D $Zn(NH_3)_4^{2+}$

10. $ClO_3^-(aq) + 6H^+(aq) + ne^- \rightarrow Cl^-(aq) + 3H_2O(\ell)$

What value of n is required to balance the above equation?

A 4

B 5

C 6

D 7

11. What volume of 0·5 mol l^{-1} sodium carbonate is required to make, by dilution with water, one litre of a solution with a $\mathbf{Na^+(aq)}$ concentration of 0·2 mol l^{-1}?

A 100 cm^3

B 200 cm^3

C 300 cm^3

D 400 cm^3

12. $CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$

The above reaction can be said to have reached equilibrium when

A the equilibrium constant K is equal to 1

B the concentrations of the products equal those of the reactants

C the reaction between the acid and the alcohol has stopped

D the rate of production of ethyl ethanoate equals its rate of hydrolysis.

13. $C_2H_6(g) \rightleftharpoons C_2H_4(g) + H_2(g)$ $\Delta H^\circ = +157\,kJ\ mol^{-1}$

The conditions favouring the highest equilibrium yield of ethene in the above reaction are

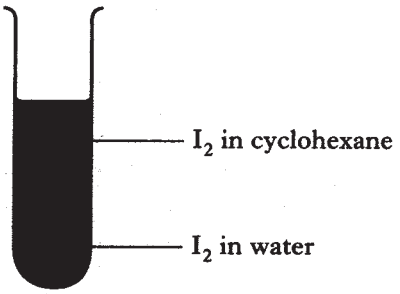
A low pressure and high temperature

B low pressure and low temperature

C high pressure and high temperature

D high pressure and low temperature.

14.



The partition coefficient for the above system can be altered by

A adding more cyclohexane

B adding more iodine

C changing the temperature

D shaking the mixture thoroughly.

15. $\frac{1}{2}N_2(g) + O_2(g) \rightarrow NO_2(g)$

$\Delta G^\circ = +51{\cdot}8\,kJ\ mol^{-1}$

$N_2(g) + 2O_2(g) \rightarrow N_2O_4(g)$

$\Delta G^\circ = +97{\cdot}7\,kJ\ mol^{-1}$

What is the free energy change ΔG°, in kJ mol^{-1}, for the conversion of nitrogen dioxide to one mole of dinitrogen tetroxide?

A −45·9

B −5·9

C +5·9

D +45·9

16. The standard enthalpy of formation of strontium chloride is the enthalpy change for which of the following reactions?

A $Sr(g) + Cl_2(g) \rightarrow SrCl_2(s)$

B $Sr(s) + Cl_2(g) \rightarrow SrCl_2(s)$

C $Sr^{2+}(g) + 2Cl^-(g) \rightarrow SrCl_2(s)$

D $Sr^{2+}(aq) + 2Cl^-(aq) \rightarrow SrCl_2(s)$

17. The mean bond enthalpy of a C — F bond is 486 kJ mol^{-1}.

In which of the processes is ΔH approximately equal to +1944 kJ mol^{-1}?

A $CF_4(g) \rightarrow C(s) + 2F_2(g)$

B $CF_4(g) \rightarrow C(g) + 4F(g)$

C $CF_4(g) \rightarrow C(g) + 2F_2(g)$

D $CF_4(g) \rightarrow C(s) + 4F(g)$

18. $$Cr(g) \rightarrow Cr^{3+}(g) + 3e^-$$

The energy required for this change is

A 1977 kJ mol^{-1}

B 3000 kJ mol^{-1}

C 5259 kJ mol^{-1}

D 9000 kJ mol^{-1}.

19. A Born-Haber cycle can be used to calculate the lattice enthalpy of sodium chloride. Which of the following is **not** required in the calculation?

A The first ionisation energy of chlorine

B The enthalpy of formation of sodium chloride

C The first ionisation energy of sodium

D The bond enthalpy of chlorine

20. The enthalpy change for the reaction

$Li^+(g) + Br^-(g) \rightarrow Li^+(aq) + Br^-(aq)$

is

A the enthalpy of formation of lithium bromide

B the enthalpy of solution of lithium bromide

C the sum of the hydration enthalpies of lithium and bromide ions

D the sum of the first ionisation energy of lithium and the electron affinity of bromine.

21. In which of the following are the molecules likely to have the lowest degree of disorder?

A $H_2O(g)$

B $Br_2(g)$

C $H_2O(\ell)$

D $Br_2(\ell)$

22. For a certain reaction

$\Delta H^\circ = +7{\cdot}3$ kJ mol^{-1} and $\Delta S^\circ = -200$ J K^{-1} mol^{-1}.

This reaction will

A never be thermodynamically feasible

B be thermodynamically feasible above a certain temperature

C be thermodynamically feasible below a certain temperature

D be thermodynamically feasible at all temperatures.

23. The equilibrium constant for the reaction

$$Zn(s) + Cu^{2+}(aq) \rightleftharpoons Zn^{2+}(aq) + Cu(s)$$

at 298 K has a numerical value of 2×10^{37}.

Which of the following statements about the reaction is correct?

A The free energy change associated with the reverse reaction has a large negative value.

B The free energy change associated with the forward reaction has a small negative value.

C The reverse reaction does not occur to any appreciable extent.

D The value of the equilibrium constant is not dependent on temperature.

24. $Ti^{3+}(aq) + e^- \rightleftharpoons Ti^{2+}(aq)$ $\quad E^\circ = -0{\cdot}37$ V

$V^{3+}(aq) + e^- \rightleftharpoons V^{2+}(aq)$ $\quad E^\circ = -0{\cdot}26$ V

Which line in the table is true for the reaction represented below?

$$V^{3+}(aq) + Ti^{2+}(aq) \rightleftharpoons V^{2+}(aq) + Ti^{3+}(aq)$$

	ΔG°	K
A	negative	>1
B	positive	>1
C	negative	<1
D	positive	<1

[Turn over

25. For a cell in which the following reaction occurs

$$X(s) + 2Y^+(aq) \rightarrow X^{2+}(aq) + 2Y(s)$$

the E° value is 1·5 V.

$\Delta G°$ for the reaction, per mole of X, is

A $-289{\cdot}5\ kJ\ mol^{-1}$

B $-144{\cdot}8\ kJ\ mol^{-1}$

C $+144{\cdot}8\ kJ\ mol^{-1}$

D $+289{\cdot}5\ kJ\ mol^{-1}$.

26. A cell consists of inert electrodes in half cells whose Standard Reduction Potentials are shown below.

$$MnO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightleftharpoons MnO_2(s) + 2H_2O(\ell) \qquad E° = 2{\cdot}26\ V$$

$$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq) \qquad E° = 0{\cdot}77\ V$$

Under standard conditions the emf of the cell would be

A 0·72 V

B 1·49 V

C 3·03 V

D 3·80 V.

27. A suggested mechanism for the reaction

$$2A + B \rightarrow A_2B$$

is a two-step process

$$A + B \rightarrow AB \text{ (slow)}$$

$$AB + A \rightarrow A_2B \text{ (fast)}$$

This mechanism is consistent with the rate equation

A rate = $k[A]^2[B]$

B rate = $k[A][B]$

C rate = $k[A][A_2B]$

D rate = $k[AB]$.

28. Which of the following equations does **not** represent a nucleophilic substitution?

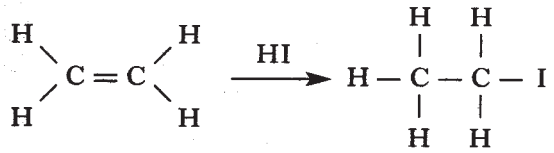
A $C_3H_7Br + KOH \xrightarrow{\text{ethanol}} C_3H_6 + KBr + H_2O$

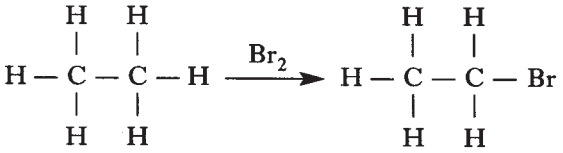
B $C_3H_7Br + KCN \xrightarrow{\text{ethanol}} C_3H_7CN + KBr$

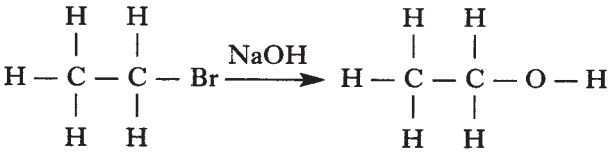
C $C_2H_5Cl + C_2H_5ONa \xrightarrow{\text{ethanol}} C_2H_5OC_2H_5 + NaCl$

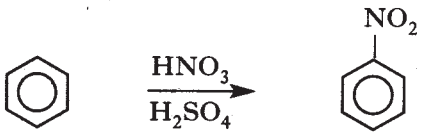
D $C_2H_5Br + NaOH \xrightarrow{\text{water}} C_2H_5OH + NaBr$

Questions 29 and **30** refer to the following.

A 

B 

C 

D 

29. Which of the above involves homolytic fission?

30. Which of the above involves electrophilic substitution?

31. Which of the following is most reactive as a nucleophile?

A NH_3

B NH_4^+

C Br_2

D CH_3I

32. Which formula represents 2-methylpentan-3-ol?

A $CH_3CH(CH_3)CH(OH)CH_2CH_3$

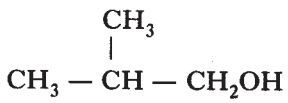
B $CH_3CH(OH)CH(CH_3)CH_2CH_3$

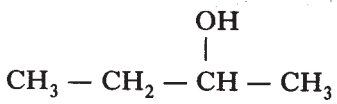
C $CH_3CH(CH_3)CH(OH)CH_3$

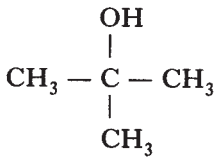
D $CH_3CH_2C(CH_3)_2CH_2CH_2OH$

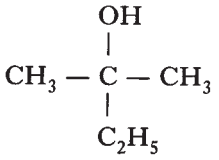
33. An alcohol, **X**, does **not** react with acidified dichromate solution, but gives an alkene when dehydrated with hot concentrated sulphuric acid. This alkene reacts with bromine water to form 1,2-dibromo-2-methylpropane.

Which of the following is **X**?

A


B


C


D


Questions 34 and **35** refer to the following.

An organic compound is sometimes identified by the preparation of a crystalline derivative.

34. To help in identification, a derivative **must**

A decompose at its melting point

B have a low relative molecular mass

C have a sharp boiling point

D have a sharp melting point.

35. Which of the following can be distinguished by making 2,4-dinitrophenylhydrazone derivatives?

A Propan-1-ol and propan-2-ol

B Ethanoic acid and benzoic acid

C Methoxyethane and ethoxyethane

D Ethanal and propanal

36. What would be the products formed when $CH_3COOCH_2CH_2OOCCH_3$ is warmed with aqueous sodium hydroxide solution?

A $CH_3COONa + HOCH_2CH_2OH$

B $CH_3COOH + NaOCH_2CH_2ONa$

C $CH_3COONa + C_2H_5OOCCH_3$

D $CH_3COOCH_3 + H_2O$

37. Which of the following compounds would dissolve in water to give an alkaline solution?

A CH_3COCH_3

B CH_3CH_2CN

C CH_3CH_2CHO

D $CH_3CH_2NH_2$

38. Which of the following molecules is planar?

A Chlorobenzene

B Methylbenzene (toluene)

C Cyclohexane

D Hexane

39. Which of the following analytical techniques depends on the vibrations within molecules?

A Nuclear magnetic resonance spectroscopy

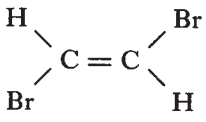
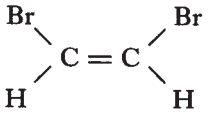
B Atomic emission spectroscopy

C Infra-red spectroscopy

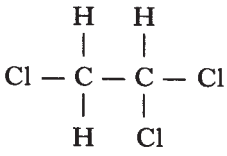
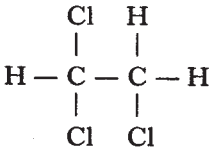
D Mass spectrometry

40. Which of the following represent the same chemical substance?

A $CH_2 = CH - CH_2 - CH_3$ and $CH_3 - CH = CH - CH_3$

B  and 

C $CH_3 - CH_2 - \underset{\displaystyle CH_3}{\underset{|}{CH}} - CH_3$ and $CH_3 - \underset{\displaystyle CH_3}{\underset{|}{\overset{\displaystyle CH_3}{\overset{|}{C}}}} - CH_3$

D  and 

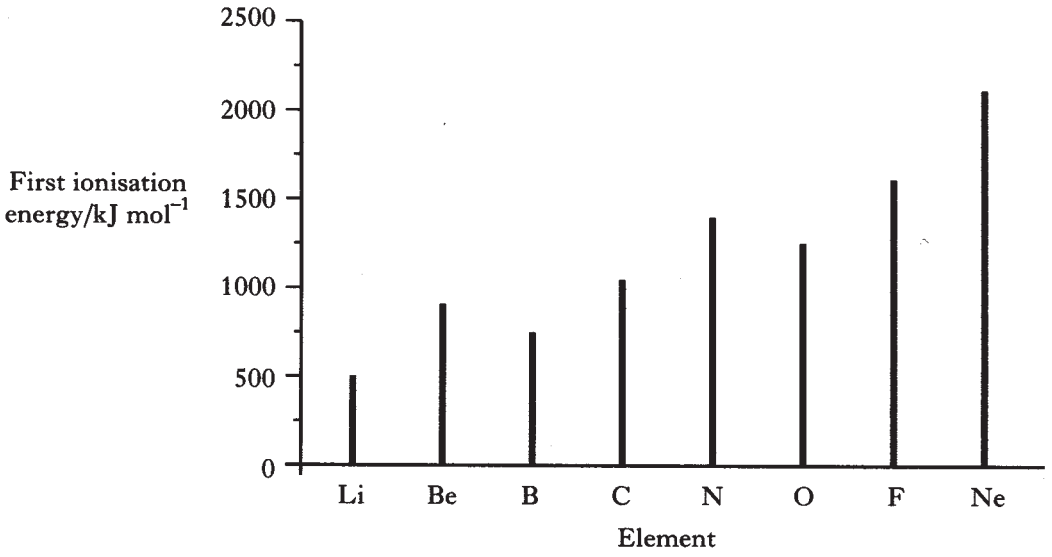
[END OF SECTION A]

Candidates are reminded that the answer sheet for Section A must be placed inside the front cover of your answer book.

SECTION B

Marks

1. The graph below shows the first ionisation energies for the elements of the second period in the Periodic Table.



(*a*) (i) Why does the first ionisation energy tend to increase across the period? **1**

(ii) Give a reason why the first ionisation energy of nitrogen is higher than that of oxygen. **1**

(*b*) Explain why the **second** ionisation energy of lithium is the highest in this period. **1**

(3)

2. (*a*) Using bond enthalpy values from the **Data Booklet**, calculate the enthalpy change for the following reaction.

$$C_2H_2(g) + 2H_2(g) \longrightarrow C_2H_6(g)$$ **3**

(*b*) The enthalpy change for the reaction above can also be calculated using standard enthalpies of combustion.

Why might this value be different from the answer to (*a*)? **1**

(4)

[Turn over

Marks

3. (*a*) Using the data from the table below calculate the standard enthalpy change, in kJ mol^{-1}, for the following reaction.

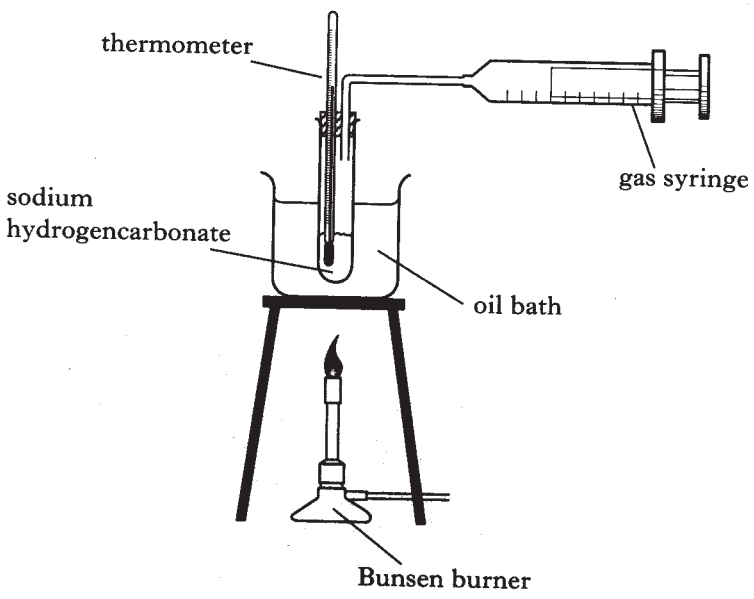
$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

Compound	Standard enthalpy of formation/kJ mol^{-1}
$NaHCO_3(s)$	−948
$Na_2CO_3(s)$	−1131
$H_2O(g)$	−242
$CO_2(g)$	−394

1

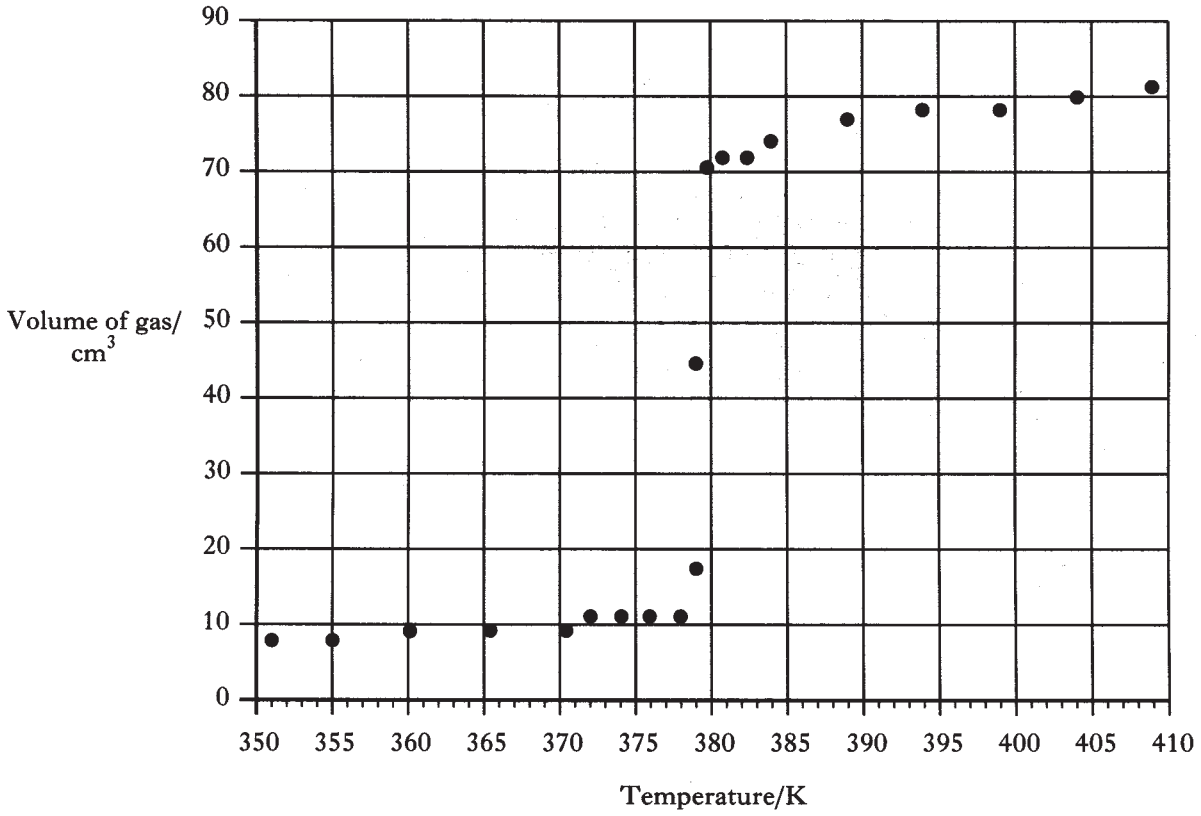
(*b*) Given that the entropy change for the reaction is +335 J K^{-1} mol^{-1}, calculate the temperature at which the reaction just becomes feasible. **2**

(*c*) A student set up an experiment to measure the temperature at which sodium hydrogencarbonate begins to decompose on heating, using the apparatus below.



3. (*c*) (continued)

From the student's results below, what is the experimental value for the temperature at which the sodium hydrogencarbonate begins to decompose?



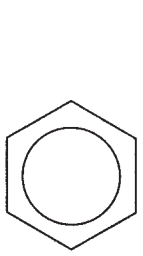
1

(*d*) Suggest a reason why the calculated and experimental decomposition temperatures may be different. 1

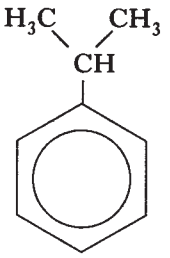
(5)

[Turn over

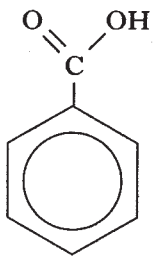
4. The structural formulae of three aromatic compounds are shown below.



benzene



2-phenylpropane



benzoic acid

The relative formula masses and boiling points of these compounds are shown in the table below.

Compound	Relative formula mass	Boiling point/°C
benzene	78·1	80
2-phenylpropane	120·2	152
benzoic acid	122·1	250

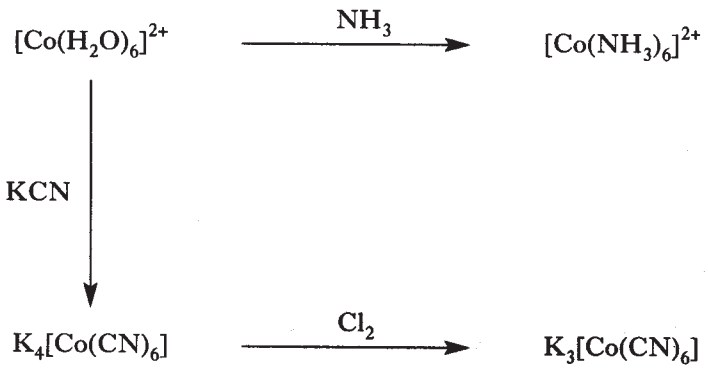
(*a*) In terms of bonding, why does 2-phenylpropane have a higher boiling point than benzene? **1**

(*b*) Benzoic acid and 2-phenylpropane molecules are of similar size and shape. Why is the boiling point of benzoic acid higher than that of 2-phenylpropane? **1**

(*c*) What would benzene be reacted with to form 2-phenylpropane? **1**

(3)

5. Consider the following reactions.



(*a*) Write the electronic configuration of the cobalt(II) ion in terms of s, p and d orbitals. **1**

(*b*) Name the $[Co(NH_3)_6]^{2+}$ ion. **1**

(*c*) What is the function of the chlorine in the following reaction?

1

(*d*) There is a colour change when NH_3 is added to $[Co(H_2O)_6]^{2+}$.
Why does this change of ligand result in different wavelengths of light being absorbed? **1**

(*e*) The $[Co(H_2O)_6]^{2+}$ ion absorbs at 550 nm.
Calculate the energy, in kJ mol^{-1}, corresponding to this absorption. **3**

(7)

Marks

6. A 1·11 g sample of steel containing manganese was dissolved in nitric acid. The manganese(II) ions formed were then oxidised to permanganate ions. The resulting purple solution was made up to 100 cm^3 in a standard flask.

In a titration, a 25·0 cm^3 portion of the permanganate solution was reduced by 30·1 cm^3 of 0·0020 mol l^{-1} iron(II) sulphate solution.

(*a*) Using information from the Data Booklet, write a redox equation for the reaction between the permanganate ions and iron(II) ions. **1**

(*b*) (i) Calculate the number of moles of permanganate ions in the 25·0 cm^3 portion titrated. **2**

(ii) Calculate the percentage by mass of manganese in the original sample of steel. **2**

(*c*) What other method could be used to determine the manganese content of the purple solution? **1**

(6)

7. Ozone, O_3, is one of the earth's key defences against damaging ultra-violet radiation.

(*a*) Ozone can be described in terms of resonance structures.

Draw the **two** resonance structures for ozone. **1**

(*b*) Ozone can be broken down by nitrogen monoxide gas produced by high flying aircraft.

Reaction 1 $NO(g) + O_3(g) \longrightarrow NO_2(g) + O_2(g)$

The nitrogen dioxide formed can then react with oxygen atoms.

Reaction 2 $NO_2(g) + O(g) \longrightarrow NO(g) + O_2(g)$

(i) Write an equation for the overall reaction. **1**

(ii) From the equations, what part does the nitrogen monoxide play in the overall reaction? **1**

(*c*) The following table shows how the initial rate of **reaction 2** varies with changing concentrations of $NO_2(g)$ and O(g) at a fixed temperature.

[O]/mol l^{-1}	[NO_2]/mol l^{-1}	Initial rate/mol l^{-1} s^{-1}
$9{\cdot}20 \times 10^{-15}$	$1{\cdot}11 \times 10^{-12}$	$6{\cdot}10 \times 10^{-17}$
$1{\cdot}81 \times 10^{-14}$	$1{\cdot}11 \times 10^{-12}$	$1{\cdot}20 \times 10^{-16}$
$1{\cdot}81 \times 10^{-14}$	$2{\cdot}23 \times 10^{-12}$	$2{\cdot}41 \times 10^{-16}$

(i) Determine the overall order of this reaction. **1**

(ii) Calculate a value for the rate constant, k, including appropriate units. **3**

(7)

8. Before a pH electrode can be used to measure the pH of a solution it must be calibrated by placing it in a series of buffer solutions of known pH.

One buffer solution used to calibrate a pH electrode was made by dissolving 2·24 g of potassium propanoate, C_2H_5COOK, in 250 cm^3 of 0·20 mol l^{-1} propanoic acid.

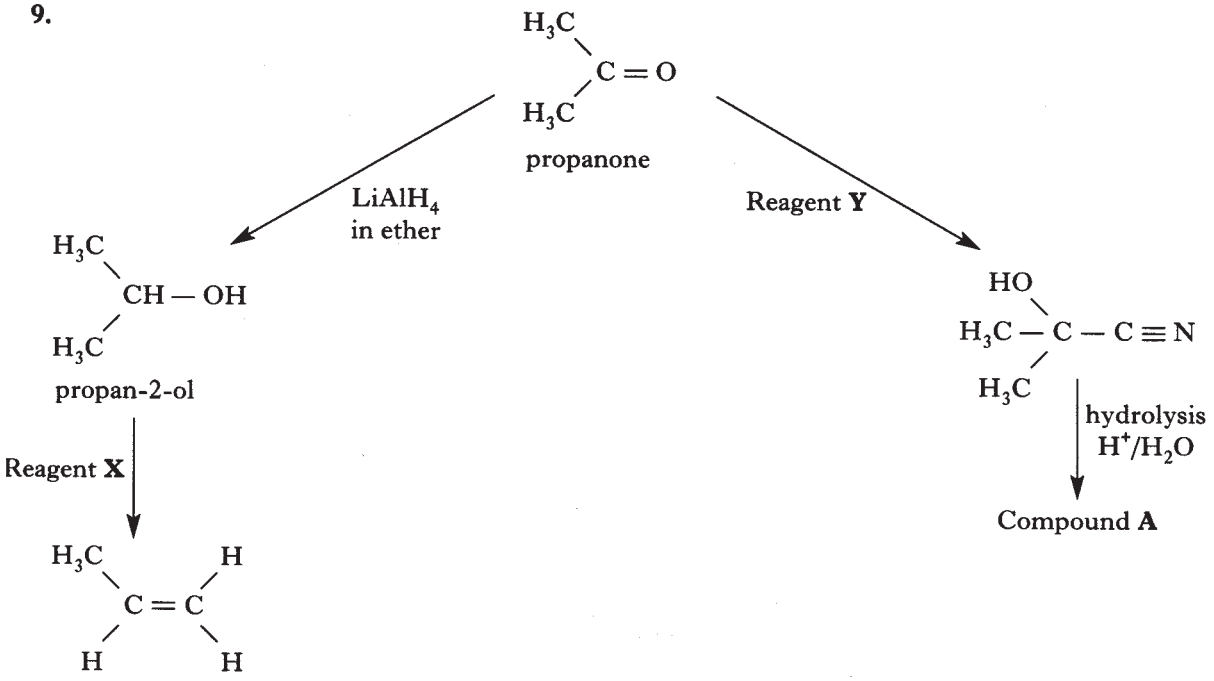
(*a*) What property of buffer solutions makes them ideal for calibrating pH electrodes? **1**

(*b*) Calculate the pH of the buffer solution described above. **3**

(4)

Marks

9.



(*a*) Identify:

(i) reagent **X**; **1**

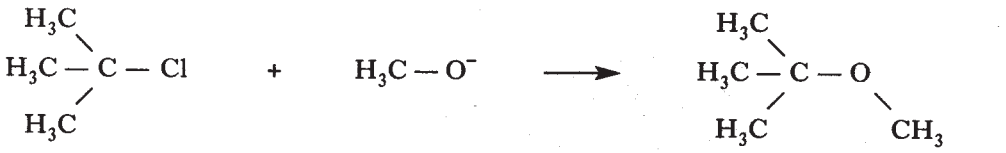
(ii) reagent **Y**. **1**

(*b*) Draw a structural formula for compound **A**. **1**

(c) Name the type of reaction involved in the conversion of propanone to propan-2-ol. **1**

(4)

10. 2-Methoxy-2-methylpropane is a compound added to unleaded petrol as a "knock inhibitor". It can be synthesised by the reaction of methoxide ions with 2-chloro-2-methylpropane.



(*a*) To which class of organic compounds does 2-methoxy-2-methylpropane belong? **1**

(*b*) How can the methoxide ion be prepared from methanol? **1**

(*c*) The preparation of the 2-methoxy-2-methylpropane proceeds by a S_N1 mechanism.

(i) Clearly showing the electron shifts, outline the step(s) involved. **2**

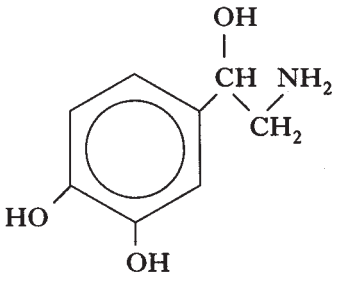
(ii) Suggest why this reaction is more likely to proceed by a S_N1 mechanism rather than a S_N2. **1**

(*d*) 2-Methoxy-2-methylpropane does not display optical isomerism. Draw the structural formula of an isomer of this compound which does display optical isomerism. **1**

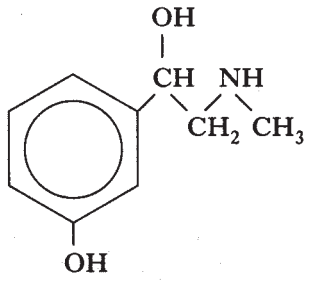
(6)

Marks

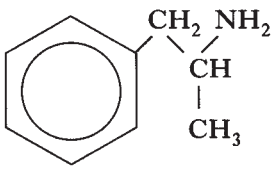
11. The three molecules shown below can all increase blood pressure if introduced into the human body.



noradrenaline



phenylephrine



amphetamine

Noradrenaline is produced naturally by the adrenal gland in times of stress. It activates sites called adrenoreceptors that cause many changes in the body including increased blood pressure.

Phenylephrine has been found to stimulate the same receptors producing very similar effects.

Amphetamine is classed as an indirectly acting agonist. Instead of acting directly on adrenoreceptors it causes certain nerve terminals in the body to produce noradrenaline thus raising blood pressure.

(*a*) What is meant by the term "agonist"? **1**

(*b*) Draw the structural formula for the pharmacophore acting on the adrenoreceptors. **1**

(*c*) Amines can be classified as primary, secondary or tertiary. To which class of amine does phenylephrine belong? **1**

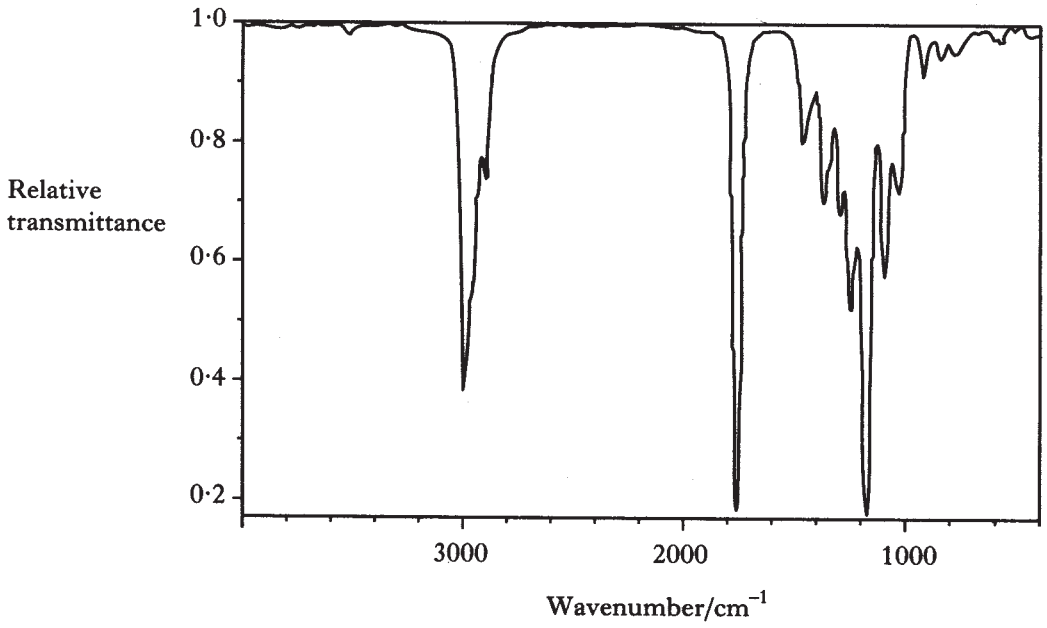
(3)

[Turn over

Marks

12. A chemist used a variety of techniques to identify a sweet-smelling compound, **X**.

(*a*) The infra-red spectrum of **X** is shown below.



(i) Which bond is responsible for the strong absorption at 1745 cm^{-1}? **1**

(ii) To which class of organic compounds does **X** belong? **1**

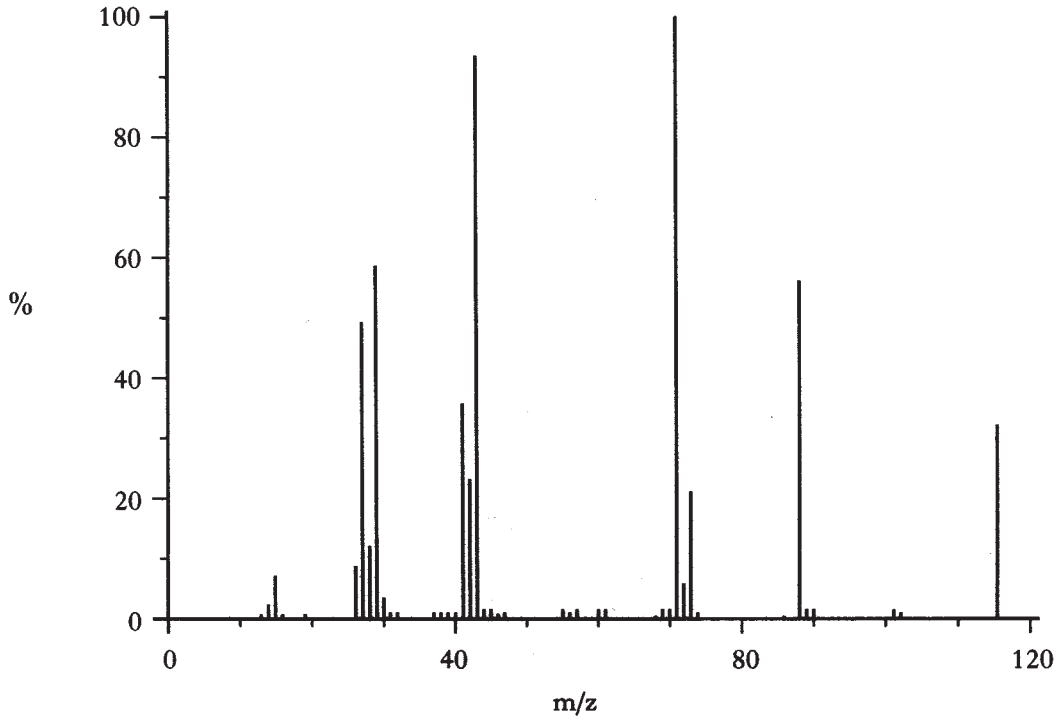
(*b*) Compound **X** was subjected to elemental analysis. Complete combustion of 0·210 g of **X** gave 0·478 g of carbon dioxide and 0·196 g of water. No other product was formed.

(i) Calculate the masses of carbon and hydrogen in the original sample and hence deduce the mass of oxygen present. **2**

(ii) Calculate the empirical formula for compound **X**. **1**

12. (continued)

(*c*) The mass spectrum of compound **X** is shown below.



(i) From the mass spectrum, what is the relative molecular mass of compound **X**? **1**

(ii) What is the molecular formula for compound **X**? **1**

(*d*) Compound **X** was hydrolysed producing ethanol and another compound.
Considering all the evidence, name **X**. **1**

(8)

[END OF QUESTION PAPER]

SCOTTISH QUALIFICATIONS AUTHORITY

2004 Chemistry

Advanced Higher

Finalised Marking Instructions

Advanced Higher Chemistry

General information for markers

The general comments given below should be considered during all marking.

1 Marks should **not** be deducted for incorrect spelling or loose language as long as the meaning of the word(s) is conveyed.

Example: Answers like 'distiling' (for 'distillation') and 'it gets hotter' (for 'the temperature rises') should be accepted.

2 A right answer followed by a wrong answer should be treated as a cancelling error and no marks should be given.

Example: What is the colour of universal indicator in acid solution?

The answer 'red, blue' gains no marks.

3 If a right answer is followed by additional information which does not conflict, the additional information should be ignored, whether correct or not.

Example: Why can the tube not be made of copper?

If the correct answer is related to a low melting point, and the candidate's answer is 'It has a low melting point and is coloured grey' this would **not** be treated as a cancelling error.

4 Full marks should be awarded for the correct answer to a calculation on its own whether or not the various steps are shown **unless the question is structured or working is specifically asked for.**

5 A mark should be deducted in a calculation for each arithmetic slip **unless stated otherwise in the marking scheme.** No marks should be deducted for incorrect or missing units at intermediate stages in a calculation.

6 A mark should be deducted for incorrect or missing units **unless stated otherwise in the marking scheme**. Please note, for example, that KJ mol^{-1} is not acceptable for kJ mol^{-1} and a mark should be deducted.

7 Where a wrong numerical answer (already penalised) is carried forward to another step, no further penalty is incurred provided the result is used correctly.

8 No mark is given for the solution of an equation which is based on a wrong principle.

Example: Use the information in the table to calculate the standard entropy change for the reaction:

$$C_2H_2 + 2HCl \longrightarrow CH_2ClCH_2Cl$$

Compound	**S^o/J K^{-1} mol^{-1}**
C_2H_2	201
HCl	187
CH_2ClCH_2Cl	208

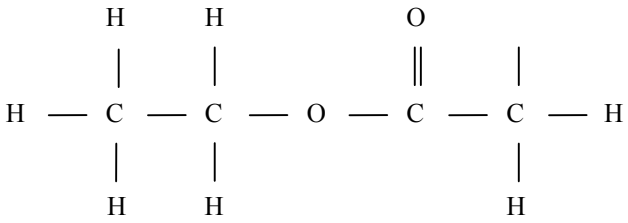
Using $\Delta S^o = S^o_{\text{reactions}} - S^o_{\text{products}}$ would gain zero marks.

9 No marks are given for the description of the wrong experiment.

10 Full marks should be given for correct information conveyed by a sketch or diagram in place of a written description or explanation.

11 In a structural formula, if one hydrogen atom is missing but the bond is shown, no marks are deducted.

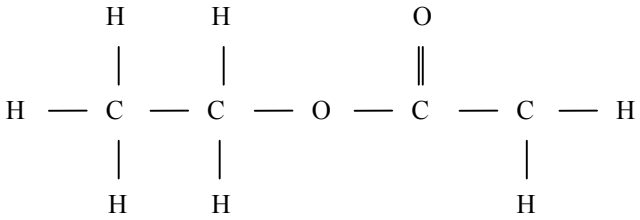
Examples:



Would not be penalised as the structural formula for ethyl ethanoate.

If the bond is also missing, then zero marks should be awarded.

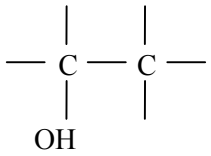
Example:



12 If a structural formula is asked for, CH_3– and CH_3CH_2– are acceptable as methyl and ethyl groups respectively.

13 With structures involving an –OH or an $–NH_2$ group, no mark should be awarded if the 'O' or 'N' are not bonded to a carbon, i.e. $OH–CH_2$ and $NH_2–CH_2$.

14 When drawing structural formulae, no mark should be awarded if the bond points to the 'wrong' atom, eg



15 A symbol or correct formula should be accepted in place of a name **unless stated otherwise in the marking scheme**.

16 When formulae of ionic compounds are given as answers it will only be necessary to show ion charges if these has been specifically asked for. However, if ion charges are shown, they must be correct. If incorrect charges are shown, no marks should be awarded.

17 If an answer comes directly from the text of the question, no marks should be given.

Example: A student found that 0·05 mol of propane, C_3H_8 burned to give 82·4 kJ of energy.

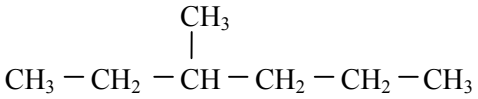
$$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(l)$$

Name the kind of enthalpy change which the student measured.

No marks should be given for 'burning' since the word 'burned' appears in the text.

18 A guiding principle in marking is to give credit for (partially) correct chemistry rather than to look for reasons not to give marks.

Example 1: The structure of a hydrocarbon found in petrol is shown below.



Name the hydrocarbon.

Although not completely correct, the answer, '3, methyl-hexane' would gain the full mark ie wrong use of commas and dashes.

Example 2: A student measured the pH of four carboxylic acids to find out how their strength is related to the number of chlorine atoms in the molecule. The results are shown.

Structural formula	**pH**
CH_3COOH	1·65
$CH_2ClCOOH$	1·27
$CHCl_2COOH$	0·90
CCl_3COOH	0·51

How is the strength of the acids related to the number of chlorine atoms in the molecule?

Again, although not completely correct, an answer like 'the more Cl_2, the stronger the acid' should gain the full mark.

Example 3: Why does the (catalytic) converter have a honeycomb structure?

A response like 'to make it work' may be correct but it is not a chemical answer and the mark should not be given.

2004 Chemistry Advanced Higher

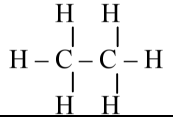
Marking scheme

Section A

1.	D	21.	C
2.	C	22.	A
3.	B	23.	C
4.	D	24.	A
5.	D	25.	A
6.	B	26.	B
7.	C	27.	B
8.	B	28.	A
9.	D	29.	B
10.	C	30.	D
11.	B	31.	A
12.	D	32.	A
13.	A	33.	C
14.	C	34.	D
15.	B	35.	D
16.	B	36.	A
17.	B	37.	D
18.	C	38.	A
19.	A	39.	C
20.	C	40.	D

Section B

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
1 (a) (i)	Increasing nuclear charge/more protons/greater attraction from nucleus or Decreasing atomic radius or Atoms getting smaller	1	More electrons More protons and more electrons Atoms getting more stable	use of word 'molecules' instead of 'atoms'
(ii)	Nitrogen has a half filled p sub-shell or set of p-orbitals or Oxygen has two electrons paired in a p-orbital → electron/electron repulsion makes it easier to remove one of these electrons	1	Orbital instead of p subshell Orbital box notation given without any further explanation Because of Hund's Rule	
(b)	2nd ionisation of Lithium involves removal of electron from 1s **orbital** which is **closer to nucleus** Lowest shell or full shell or lower energy level or stable or full 1s orbital or breaking into new shell or Li^+ has noble gas arrangement	1	full orbital	stable octet

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
2 (a)	bonds broken: $H-C\equiv C-H + H-H + H-H$ bonds made:  $2 \times H-H$ 432 x 2 $C\equiv C$ 835 $2 \times C-H$ 414 x 2 $C-C$ – 346 $6 \times C-H$ – 414 x 6 $\Delta H =$ 2527 – 2830 = -303kJ mol^{-1} Identifying correct bonds Correct energies of bonds broken/formed Arithmetic and units + 303kJ = 2 out of 3	1 1 1	C = C - deduct 1 mark -536kJ - 2 out of 3 43kJ - 2 out of 3	
(b)	$C\equiv C$, C–C and C–H are mean (average) bond energies or Enthalpies of combustion can be measured directly (bond energies are calculated)	1	Experimental errors associated with ΔH combustion experiments Neglecting intermolecular forces Not standard states Heat losses to surroundings	

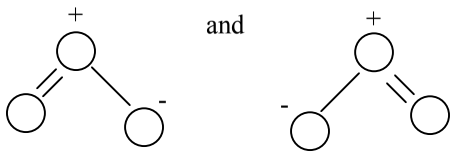
Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
3 (a)	$\Delta H_f^o = \Delta H_f^o\ Na_2CO_3 + \Delta H_f^o\ CO_2 + \Delta H_f^o\ H_2O - 2 \times \Delta H_f^o\ NaHCO_3$ $\Delta H^o = -1131 - 394 - 242 + 1896$ $\Delta H^o = +129\ kJ\ mol^{-1}$ + 129 … 1 mark – units not required Either 1 mark or zero	1	-129 kJ mol^{-1} 129000 kJ or 129000 J	
(b)	$\Delta G^o = \Delta H^o - T\Delta S^o$ $0 = \Delta H^o - T\Delta S^o$ or equivalent expression $T = \frac{\Delta H^\circ}{\Delta S^\circ}$ $T = \frac{+129000}{335}$ Any of these 3 lines for 1 mark $T = 385{\cdot}1$ K or 385 K (or $111{\cdot}9^\circ C$ or $112^\circ C$) 1 mark Follow through from wrong answer in (a) is acceptable to get 2 marks in (b)	2	Lose 1 mark for ° K No units, lose 1 mark $T = \frac{-\Delta H^\circ}{\Delta S^\circ}$ deduct 1 mark	

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
3 (c)	Value in range 378 – 380 K (or 105 - 107° C)	**1**		No units or ° K unless already deducted in part (b)
(d)	Oil bath heated too quickly Impure/wet sample S° values valid @ 25°C rather than at room temp Oil bath not stirred Leaks Sticky gas syringe Not carried out under standard conditions Unequal distribution of temperature in the powder	**1**	Experimental error Inaccuracy in reading thermometer Human error Heat lost to surroundings Inaccuracy in thermometer	

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
4 (a)	(more) stronger van der Waals for 2-phenylpropane 2-phenylpropane more polar so stronger (or greater) intermolecular forces 2-phenylpropane is more polar so has dipole-dipole attractions bigger molecules so stronger intermolecular forces	**1**	Molecules more polar (by itself) Bigger molecules (by itself) More bonds/greater intermolecular forces	
(b)	Benzoic acid has hydrogen bonding or correct diagram showing H-bonding	**1**	Stronger intermolecular forces	
(c)	Any 2-halopropane Ignore anything else such as $FeCl_3$ or $AlCl_3$ Accept correct carbocation from 2-halopropane	**1**		
5 (a)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7$ or $[Ne]\ 3s^2\ 3p^6\ 3d^7$ Correct answer including $4s^o$	**1**	$[Ar]\ 3d^7$ (doesn't show s and p)	
(b)	Hexaamminecobalt (II) Hexamminecobalt (II)	**1**	Use of amino/amine/ammino Presence of commas/hyphens	
(c)	Oxidising agent/oxidating agent Oxidises the Co^{2+} to Co^{3+}	**1**		cancelling error if wrong species being oxidised
(d)	Change in d → d splitting Different CFSE Different ligand field strength	**1**	Changing d orbital configuration Must state d orbitals not just orbitals	Ligands absorbing different colours

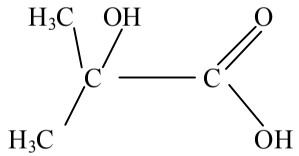
Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
5 (e)	$E = \frac{Lhc}{\lambda}$ $= \frac{6 \cdot 02 \times 10^{23} \times 6 \cdot 63 \times 10^{-34} \times 3 \times 10^{8} \times 10^{-3}}{5 \cdot 5 \times 10^{-7}}$ $= 217 \cdot 7$ or 218 kJ mol^{-1} (units not required)	**1** **1** **1**	217705 then lose 1 mark no L get $3 \cdot 616 \times 10^{-22}$ (2/3) or $3 \cdot 616 \times 10^{-19}$ J (1/3)	$E = Lh\ \lambda$ wrong principle
6 (a)	$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(1)$ Ignore state symbols	**1**		ē on both sides
(b) (i)	Number of moles of Fe^{2+} in 30·1 cm^3 of 0·002 mol 1^{-1} $= 6 \cdot 02 \times 10^{-5}$ Number of moles of $MnO_4^-(aq)$ = 1/5 × number of moles of $Fe^{2+}(aq)$ $= 1 \cdot 204 \times 10^{-5}$ Can also use other methods of doing this calculation Follow on from wrong equation (a)	**1** **1**		

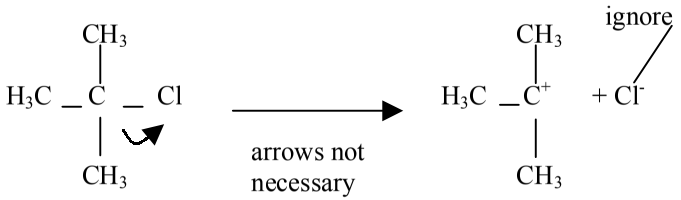
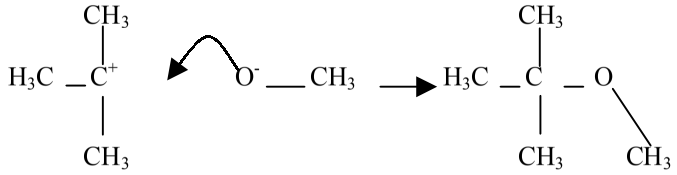
Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
6 (b) (ii)	Number of moles of $MnO_4^-(aq)$ and hence $Mn^{2+}(aq)$ in 100 cm^3 flask $= 4 \times 1 \cdot 204 \times 10^{-5} = 4 \cdot 816 \times 10^{-5}$ Mass of manganese = $54 \cdot 9 \times 4 \cdot 816 \times 10^{-5} = 2 \cdot 64 \times 10^{-3}$ g $\%Mn = \frac{2 \cdot 64 \times 10^{-3}}{1 \cdot 11} \times 100\%$ $= 0 \cdot 238\%$ or $0 \cdot 24\%$ $0 \cdot 2\%$ Do not deduct marks for rounding errors Various alternative answers following on from wrong answers in part (b) (i) and part (a)	1 1	Deduct 1 mark for not multiplying by 4. Deduct 1 mark if use a value for RAM other than $54 \cdot 9$	
(c)	Spectrophotometer/colorimeter/intensity of absorption AAS/AES	1	Calorimeter Mass spectrometer/spectrometer EDTA Gravimetric analysis Prepare derivative Calibration graph on its own	

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
7 (a)	Two diagrams required for mark  and Correct diagrams without charges Correct combination of dots or dots and crosses 2 correct plus conjugated version Ignore bond lengths and angles	1	Wrong number of lone pairs 2 correct and 1 wrong Wrong charges One resonance structure and one composite/conjugated structure	
(b) (i)	$O_3(g) + O(g) \longrightarrow 2O_2(g)$ States can be omitted	1	NO on both sides	
(ii)	Catalyst	1		

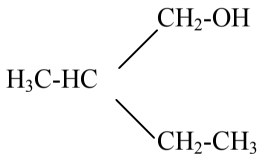
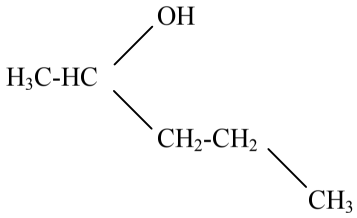
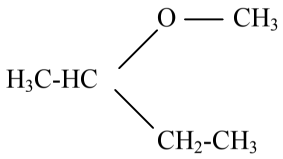
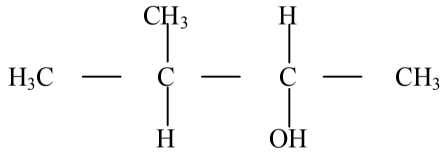
Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
7 (c) (i)	Second order or 2	1		
(ii)	$\text{Rate} = k[O]\,[NO_2]$ $k = \dfrac{\text{Rate}}{[O][NO_2]}$] 1 Do not deduct for K (capital K) as not part of final answer	1		
	$= \dfrac{6 \cdot 10 \times 10^{-17}}{9 \cdot 20 \times 10^{-15} \times 1 \cdot 11 \times 10^{-12}}$] 1 for correct substitution and arithmetic	1		
	$= 5 \cdot 97 \times 10^{9}$ $mol^{-1}\,l\,s^{-1}$ (1 for correct units) $5 \cdot 9 \times 10^{9}$ $6 \cdot 0 \times 10^{9}$ 6×10^{9}	1		
	Follow through in (ii) from wrong answer in (i)			

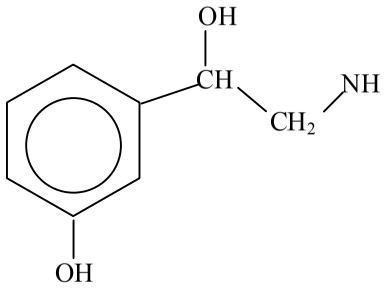
Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
8 (a)	pH remains/stays the same/doesn't change/reasonably constant if small volumes of H^+ or OH^- added (of acid or of alkali instead of H^+ or OH^-) Amphoteric	1	If small volumes of acid and alkali or equivalent are omitted	
(b)	$pH = pKa - \log \frac{[acid]}{[salt]}$ or $[H^+] = K_a \times \frac{[acid]}{[salt]}$ or $pH = pKa + \log \frac{[salt]}{[acid]}$ no of moles of $C_3H_5O_2K = \frac{2 \cdot 24}{112 \cdot 1}$ GFM $C_3H_5O_2K = 112 \cdot 1$ no of moles of $C_3H_5O_2K = 0 \cdot 0200$ $c = \frac{n}{v} = \frac{0 \cdot 0200}{0 \cdot 250}$ c = 0·0800 mol 1^{-1} for getting concentration value (no units required) $pH = 4 \cdot 9 - \log \frac{0 \cdot 200}{0 \cdot 08}$ or $[H^+] = 1 \cdot 3 \times 10^{-5} \times \frac{0 \cdot 200}{0 \cdot 08}$ $pH = 4 \cdot 9 - 0 \cdot 398$ or $[H^+] = 3 \cdot 25 \times 10^{-5}$ $pH = 4 \cdot 5$ (or $4 \cdot 502$) or $pH = -\log(3 \cdot 25 \times 10^{-5}) = 4 \cdot 5$ $(4 \cdot 49)$ For pH value of $4 \cdot 5$ or $4 \cdot 49$ or $4 \cdot 502$	1 1 1 1	If use C $= 2 \cdot 24$ then 0 marks out of 2 for calculation. [So 1 out of 3 if correct equation given]	Look for cancelling errors giving correct answer

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
9 (a) (i)	Reagent X = aluminium oxide Al_2O_3 or alumina or (concentrated) sulphuric acid H_2SO_4 or orthophosphoric acid or H_3PO_4 or phosphoric acid	1	Dilute sulphuric or phosphoric acids	
(ii)	Reagent Y = hydrogen cyanide or HCN Acidified KCN	1	CN^- KCN/cyanide HCN^-	
(b)	 full or shortened structural formula	1	Molecular formula	
(c)	Reduction	1	Addition Hydrogenation – but not as a cancelling error	

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
10 (a)	Ethers or alkoxyalkanes	**1**		
(b)	Add sodium metal/alkali metal/group 1 metal or $2Na + 2CH_3OH \rightarrow 2CH_3ONa + H_2$ (or word equation)	**1**		
(c) (i)	First step – show the heterolytic fission of the C-Cl bond to form the carbocation  Second step – show the nucleophilic attack of the methoxide ion  Must show 2 steps Correct text acceptable for 2 marks	**2**	If wrong carbocation – may still get 2nd mark. Shown as 1 step = 0 marks No carbocation at all = 0 marks Any suggestion of S_N2 = 0 marks	S_N2 mechanism

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
10 (c) (ii)	Can give one of two reasons, students wording may vary but should mention one of two concepts either the carbocation formed has three methyl (alkyl) groups attached which can feed in electron density stabilising the positive charge thus making an S_N1 mechanism more favourable. Tertiary (carbo)cation stable or the tertiary haloalkane has three methyl groups attached which offer steric hindrance w.r.t. the formation of the five co-ordinate transition state seen as part of the S_N2 mechanism bulky groups/too crowded/steric hindrance	**1** **1**	Tertiary on own without explanation Not possible to invert as it would be with S_N2	

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
10 (d)	    any one	**1**		Drawn as  0 marks

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
11 (a)	An agonist will produce a response like the body's natural active compound Enhances body's natural response Binds to receptor to produce response Stimulates receptors/triggers natural response Mimics active molecule Binds with receptor and causes the same reaction as the natural molecule	**1**		
(b)		**1**		
(c)	Secondary amine	**1**		

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
12 (a) (i)	C=O bond/C=O/carbonyl/ester	**1**	aldehyde C = O ketone C = O	
(ii)	ester	**1**		
(b) (i)	Mass of carbon $= 0 \cdot 478\text{g} \times \frac{12}{44} = 0 \cdot 1304\text{g}$ or $0 \cdot 130\text{g}$ Mass of hydrogen $= 0 \cdot 196\text{g} \times \frac{2}{18} = 0 \cdot 0218\text{g}$ or $0 \cdot 022\text{g}$ ← for two masses (for 1 mark) Mass of oxygen $= 0 \cdot 210 - 0 \cdot 130 - 0 \cdot 0218 = 0 \cdot 058\text{g}$ May still get 2nd mark if an error in first part.	**2**		

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
12 (b) (ii)	C : H : O $\frac{0 \cdot 130}{12}$: $\frac{0 \cdot 0218}{1}$: $\frac{0 \cdot 058}{16}$ $0 \cdot 01083$: $0 \cdot 0218$: $3 \cdot 625 \times 10^{-3}$ 3 : 6 : 1 Empirical formula C_3H_6O Follow through from incorrect answer to (i)	**1**	Any error	
(c) (i)	RMM = 116 115 – 117 116 amu	**1**	116 g	
(ii)	$C_6H_{12}O_2$ No other acceptable answers	**1**		
(d)	Ethyl butanoate	**1**		

[END OF MARKING INSTRUCTIONS]