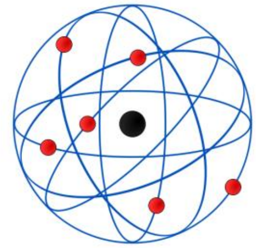
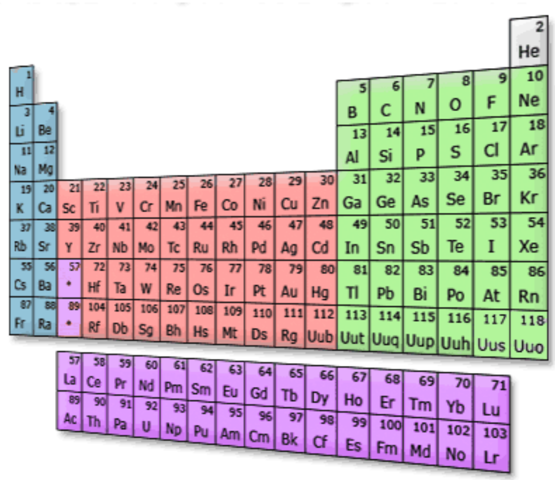


Higher Chemistry

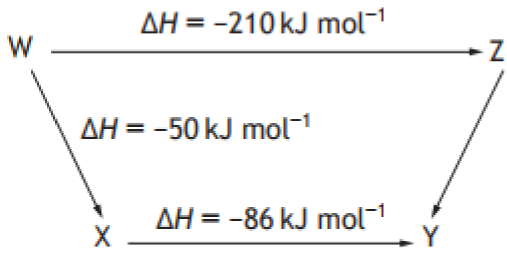
Calculations Past Paper Questions



Section 1

1.

Consider the reaction pathway shown below.



According to Hess's Law, the ΔH value, in kJ mol^{-1}, for reaction Z to Y is

A +74

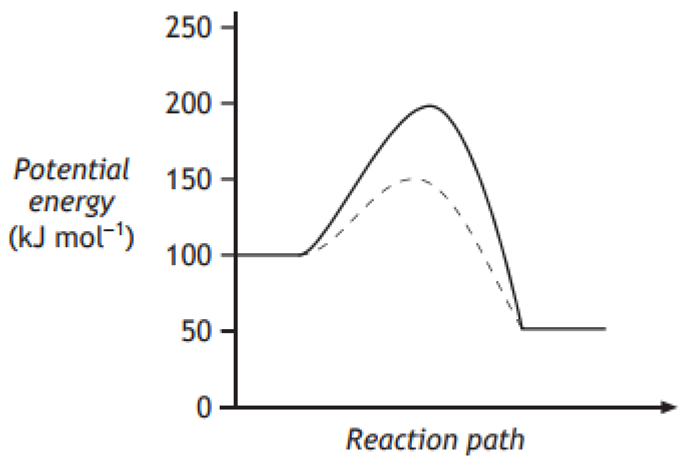
B −74

C +346

D −346.

2.

The diagram below shows the energy profiles for a reaction carried out with and without a catalyst.



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

A –100

B –50

C +50

D +100

3. $CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(\ell)$

$CaCO_3(s)$	+	$2HNO_3(aq)$	$\rightarrow$	$Ca(NO_3)_2(aq)$	+	$CO_2(g)$ + $H_2O(\ell)$
Mass of 1 mol = 100 g				Mass of 1 mol = 164 g		

2·00 g of calcium carbonate ($CaCO_3$) was reacted with 200 cm^3 of 0·1 mol l^{-1} nitric acid (HNO_3).

Take the volume of 1 mole of carbon dioxide to be 24 litres.

In the reaction

A $CaCO_3$ is the limiting reactant

B an excess of 0·1 mol of nitric acid remains at the end of the reaction

C 1·64 g of calcium nitrate is produced by the reaction

D 480 cm^3 of carbon dioxide is produced by the reaction.

4. The mean bond enthalpy of a C – F bond is 484 kJ mol^{-1}.

In which of the processes is ΔH approximately equal to +1936 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 $CF_4(g) \rightarrow C(s) + 4F(g)$

5.

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

6.

During a redox process in acid solution, chlorate ions, $ClO_3^-(aq)$, are converted into chlorine, $Cl_2(g)$.

$$ClO_3^-(aq) \rightarrow Cl_2(g)$$

The numbers of $H^+(aq)$ and $H_2O(\ell)$ required to balance the ion-electron equation for the formation of 1 mol of $Cl_2(g)$ are, respectively

A 3 and 6

B 6 and 3

C 6 and 12

D 12 and 6.

7.

$$xP_2H_4 + yO_2 \rightarrow P_4O_{10} + zH_2O$$

The equation is balanced when

A $x = 1, y = 5, z = 4$

B $x = 4, y = 6, z = 2$

C $x = 2, y = 7, z = 4$

D $x = 2, y = 5, z = 2$

8.

$TiCl_4$	+	2Mg	→	$2MgCl_2$	+	Ti
mass of one mole = 189·9 g		mass of one mole = 24·3 g		mass of one mole = 95·3 g		mass of one mole = 47·9 g

The atom economy for the production of titanium in the above equation is equal to

A $\dfrac{47{\cdot}9}{189{\cdot}9 + 24{\cdot}3} \times 100$

B $\dfrac{47{\cdot}9}{189{\cdot}9 + (2 \times 24{\cdot}3)} \times 100$

C $\dfrac{95{\cdot}3 + 47{\cdot}9}{189{\cdot}9 + 24{\cdot}3} \times 100$

D $\dfrac{(2 \times 47{\cdot}9)}{189{\cdot}9 + 24{\cdot}3} \times 100$

9. Bromine and hydrogen react together to form hydrogen bromide.

$$H_2(g) + Br_2(g) \rightarrow 2HBr(g)$$

Bonds broken	Bonds made
H—H	2 × H—Br
Br—Br	

Bond	Bond enthalpy (kJ mol^{-1})
H—H	436
Br—Br	194
H—Br	366

The enthalpy change for this reaction, in kJ mol^{-1}, is

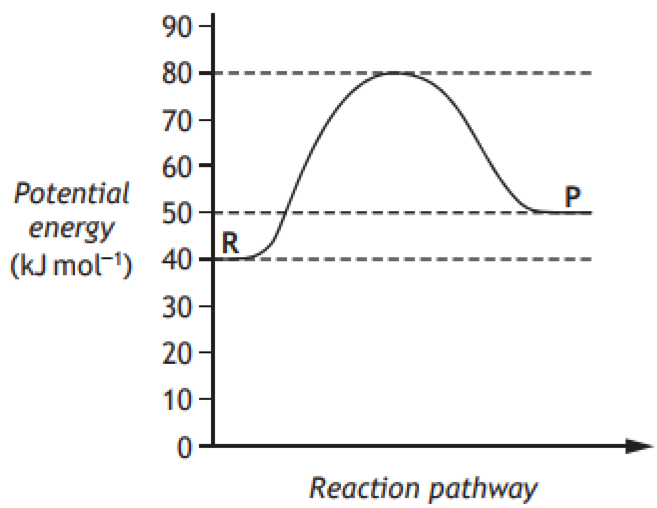
A −102

B +102

C −264

D +264.

10.
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

11.

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

A $0{\cdot}010\ s^{-1}$

B $0{\cdot}714\ s^{-1}$

C $0{\cdot}010\ min^{-1}$

D $0{\cdot}714\ min^{-1}$.

12.

The table shows the first three ionisation energies of aluminium.

Ionisation energy ($kJ\ mol^{-1}$)		
First	*Second*	*Third*
578	1817	2745

Using this information, what is the enthalpy change, in $kJ\ mol^{-1}$, for the following reaction?

$$Al^{+}(g) \rightarrow Al^{3+}(g) + 2e^{-}$$

A 1817

B 2395

C 4562

D 5140

13.

A mixture of sodium chloride and sodium sulfate is known to contain 0·6 mol of chloride ions and 0·2 mol of sulfate ions.

How many moles of sodium ions are present?

A 0·4

B 0·5

C 0·8

D 1·0

14.

Under the same conditions of temperature and pressure, which of the following gases would occupy the largest volume?

A 0·20 g of hydrogen

B 0·44 g of carbon dioxide

C 0·60 g of neon

D 0·80 g of argon

15.

$$3CuO + 2NH_3 \rightarrow 3Cu + N_2 + 3H_2O$$

What volume of gas, in cm^3, would be obtained by reaction between 100 cm^3 of ammonia gas and excess copper(II) oxide?

All volumes are measured at atmospheric pressure and 20 °C.

A 50

B 100

C 200

D 400

16.

When 3·6 g of butanal (mass of one mole = 72 g) was burned, 124 kJ of energy was released.

What is the enthalpy of combustion of butanal, in $kJ\,mol^{-1}$?

A −6·2

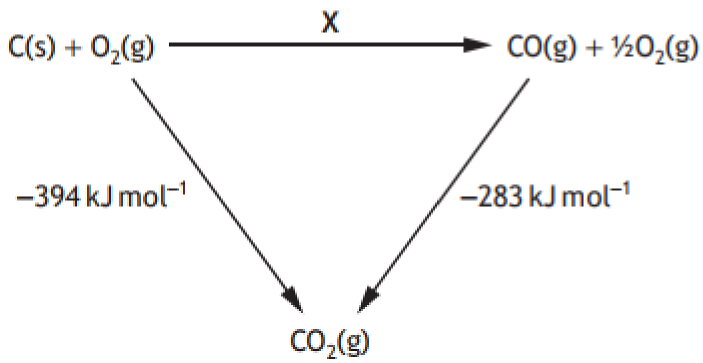
B +6·2

C −2480

D +2480

17

Consider the reaction pathways shown below.



According to Hess's Law, the enthalpy change, in $kJ\ mol^{-1}$, for reaction **X** is

A +111

B −111

C −677

D +677.

18.

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	$4H^+$	$2H_2O + 3e^-$

19.

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

20.

The number of moles of ions in 1 mol of copper(II) phosphate is

A 1

B 2

C 3

D 5.

21.

Which of the following gas samples has the same volume as 4·0 g of methane, CH_4?

(All volumes are measured at the same temperature and pressure.)

A 1·0 g of helium

B 1·0 g of hydrogen

C 3·5 g of nitrogen

D 35·5 g of chlorine

22.

Magnesium carbonate reacts with nitric acid.

$MgCO_3(s) + 2HNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + H_2O(\ell) + CO_2(g)$

0·05 mol of magnesium carbonate was added to a solution containing 0·06 mol of nitric acid.

Which of the following statements is true?

A 0·05 mol of carbon dioxide is produced

B 0·06 mol of magnesium nitrate is produced

C Magnesium carbonate is in excess by 0·02 mol

D Nitric acid is in excess by 0·01 mol

23.

Iron can be produced from iron(III) oxide.

$2Fe_2O_3(s)$	+	$3C(s)$	$\rightarrow$	$4Fe(s)$	+	$3CO_2(g)$
GFM = 159·6 g		GFM = 12·0 g		GFM = 55·8 g		GFM = 44·0 g

The atom economy for the production of iron is

A 69·9%

B 62·8%

C 58·2%

D 32·5%.

24.

100 cm^3 of propane is mixed with 600 cm^3 of oxygen and the mixture is ignited.

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

At the end of the reaction, the total volume of gas would be

A 300 cm^3

B 400 cm^3

C 700 cm^3

D 800 cm^3.

25.

A two-step reaction is shown below.

$$A \xrightarrow[\text{step 1}]{} B \xrightarrow[\text{step 2}]{} C$$

The first step gave a yield of 60% and the second step a yield of 90%.

The overall yield would be

A 30%

B 54%

C 67%

D 150%.

26.

Which of the following reactions has an atom economy of 100%?

A $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

B $Na_2O(s) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + H_2O(l)$

C $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

D $C_2H_4(g) + H_2O(l) \rightarrow C_2H_5OH(l)$

27.

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

The volume of gas produced from the complete combustion of $200cm^3$ of methane in excess oxygen, at room temperature, is

A $200cm^3$

B $300cm^3$

C $600cm^3$

D $100cm^3$.

28.

Iodate ions can be converted into iodine: $IO_3^-(aq) \rightarrow I_2(aq)$

The number of $H^+(aq)$ and $H_2O(l)$ required to balance this ion electron equation for the formation of 1mol of $I_2(aq)$ are

A 12 and 6

B 6 and 3

C 3 and 6

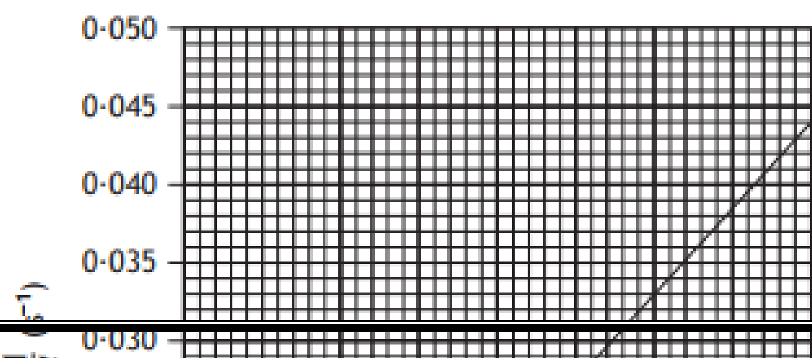
D 6 and 12

Section 2

1.

A student investigated the effect of changing acid concentration on reaction rate. Identical strips of magnesium ribbon were dropped into different concentrations of excess hydrochloric acid and the time taken for the magnesium to completely react recorded.

A graph of the student's results is shown below.



2.

(b) A student prepared a sample of methyl cinnamate from cinnamic acid and methanol.

cinnamic acid	+	methanol	→	methyl cinnamate	+	water
mass of one mole = 148 g		mass of one mole = 32 g		mass of one mole = 162 g		

6·5 g of cinnamic acid was reacted with 2·0 g of methanol.

(i) Show, by calculation, that cinnamic acid is the limiting reactant. (One mole of cinnamic acid reacts with one mole of methanol.) **2**

(ii) (A) The student obtained 3·7 g of methyl cinnamate from 6·5 g of cinnamic acid.

Calculate the percentage yield. **2**

(B) The student wanted to scale up the experiment to make 100 g of methyl cinnamate.

Cinnamic acid costs £35·00 per 250 g.

Calculate the cost of cinnamic acid needed to produce 100 g of methyl cinnamate. **2**

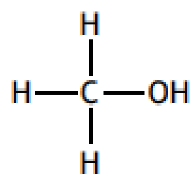
3.

Coumarin is another compound found in the brand name perfume. It is present in the spice cinnamon and can be harmful if eaten in large quantities.

The European Food Safety Authority gives a tolerable daily intake of coumarin at 0·10 mg per kilogram of body weight.

1·0 kg of cinnamon powder from a particular source contains 4·4 g of coumarin. Calculate the mass of cinnamon powder, in g, which would need to be consumed by an adult weighing 75 kg to reach the tolerable daily intake. **2**

4. Methanol can be used as a fuel, in a variety of different ways.



(a) An increasingly common use for methanol is as an additive in petrol.

Methanol has been tested as an additive in petrol at 118 g per litre of fuel.

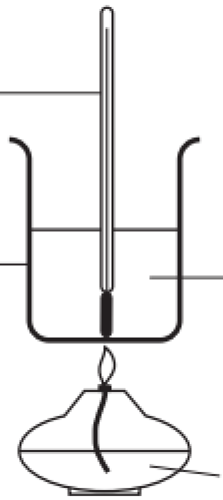
Calculate the volume of carbon dioxide, in litres, that would be released by combustion of 118 g of methanol.

$$2CH_3OH(\ell) \quad + \quad 3O_2(g) \quad \rightarrow \quad 2CO_2(g) \quad + \quad 4H_2O(\ell)$$

(Take the molar volume of carbon dioxide to be 24 litres mol^{-1}). **2**

5.

(i) The student carried out experiments to determine the enthalpy of combustion of the alcohols.



(C) The student burned 1·07 g of methanol and recorded a temperature rise of 23 °C.

Calculate the enthalpy of combustion, in $kJ\,mol^{-1}$, for methanol using the student's results. **3**

(ii) The student determined the density of the alcohols by measuring the mass of a volume of each alcohol.

The student's results are shown below.

	Methanol	*Ethanol*
Volume of alcohol (cm^3)	25·0	25·0
Mass of alcohol (g)	19·98	20·05
Density of alcohol ($g\,cm^{-3}$)		0·802

Calculate the density, in $g\,cm^{-3}$, of methanol. **1**

6. (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.

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

(ii) Calculate the concentration, in mg l^{-1}, of the solution prepared by transferring 10 cm^3 of the 1 g l^{-1} stock solution to a 1000 cm^3 standard flask and making up to the mark. **1**

7. (a) 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.

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

(iii) Calculate the concentration, in mol l^{-1}, of sodium hypochlorite in the swimming pool water, if an average volume of 12·4 cm^3 of sodium thiosulfate was required. **3**

(b) The level of hypochlorite in swimming pools needs to be maintained between 1 and 3 parts per million (1 – 3 ppm).

400 cm^3 of a commercial hypochlorite solution will raise the hypochlorite level of 45 000 litres of water by 1 ppm.

Calculate the volume of hypochlorite solution that will need to be added to an Olympic-sized swimming pool, capacity 2 500 000 litres, to raise the hypochlorite level from 1 ppm to 3 ppm. **2**

8.

(ii) The concentration of hydrogen peroxide is often described as a volume strength. This relates to the volume of oxygen that can be produced from a hydrogen peroxide solution.

volume of oxygen produced	=	volume strength	×	volume of hydrogen peroxide solution

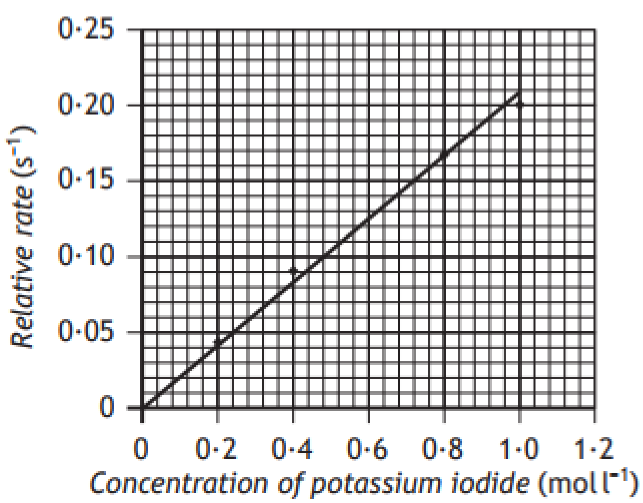
In an experiment, 74 cm^3 of oxygen was produced from 20 cm^3 of hydrogen peroxide solution.

Calculate the volume strength of the hydrogen peroxide. **1**

9.

Hydrogen peroxide can react with potassium iodide to produce water and iodine.

A student carried out an experiment to investigate the effect of changing the concentration of potassium iodide on reaction rate. The results are shown below.



Calculate the time taken, in s, for the reaction when the concentration of potassium iodide used was 0·6 mol l^{-1}. **1**

10. Phosphine (PH_3) is used as an insecticide in the storage of grain.

Phosphine can be produced by the reaction of water with aluminium phosphide

$$AlP(s) + 3H_2O(\ell) \longrightarrow PH_3(g) + Al(OH)_3(aq)$$

(b) 2·9 kg of aluminium phosphide were used in a phosphine generator.

Calculate the volume of phosphine gas, in litres, that would have been produced.

(Take the volume of 1 mole of phosphine to be 24 litres). **2**

11. (ii) Alpha-amanitin is a highly toxic cyclic peptide found in death cap mushrooms. The lethal dose for humans is 100 mg per kg of body mass.

1·0 g of death cap mushrooms contains 250 mg of alpha-amanitin.

Calculate the minimum mass of death cap mushrooms that would contain the lethal dose for a 75 kg adult. **2**

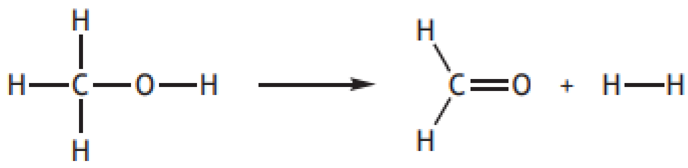
12. (iii) A student used 2·5 g of ethanol and a slight excess of ethanoic acid to produce 2·9 g of ethyl ethanoate.

ethanol	+	ethanoic acid	⇌	ethyl ethanoate	+	water
mass of one mole = 46·0 g				mass of one mole = 88·0 g		

(One mole of ethanol reacts with one mole of ethanoic acid to produce one mole of ethyl ethanoate.)

Calculate the percentage yield of ethyl ethanoate. **2**

13. (c) Methanol can be converted to methanal as shown.



Using bond enthalpy and mean bond enthalpy values from the data booklet, calculate the enthalpy change, in $kJ\,mol^{-1}$, for the reaction. **2**

14. (b) Calcium hydroxide solution can be formed by adding calcium metal to excess water.

Solid calcium hydroxide would form if the exact molar ratio of calcium to water is used. The equation for the reaction is

$$Ca(s) + 2H_2O(\ell) \rightarrow Ca(OH)_2(s) + H_2(g)$$

Calculate the enthalpy change, in $kJ\,mol^{-1}$, for the reaction above by using the data shown below.

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(\ell)$ $\quad \Delta H = -286\ kJ\,mol^{-1}$

$Ca(s) + O_2(g) + H_2(g) \rightarrow Ca(OH)_2(s)$ $\quad \Delta H = -986\ kJ\,mol^{-1}$ **2**

15.

(iv) The student used the line graph to obtain the relationship between the concentration of sugars in solution and the density of the solution.

This equation shows the relationship.

density of sugar in $g\,cm^{-3}$ = (0·0204 × % concentration of sugars in solution) + 1·00

(B) The soft drink tested had a density of 1·07 $g\,cm^{-3}$.

Using the equation, calculate the % concentration of sugars present in the soft drink. **1**

(v) A different soft drink is found to contain 10·6 grams of sugar in 100 cm^3.

Calculate the total mass of sugar present, in grams, in a 330 cm^3 can of this soft drink. **1**

16.

For the titrations, the student diluted the soft drink to improve the accuracy of results.

25·0 cm^3 samples of the diluted soft drink were titrated with Fehling's solution which had a Cu^{2+} concentration of 0·0250 $mol\,l^{-1}$.

The average volume of Fehling's solution used in the titrations was 19·8 cm^3.

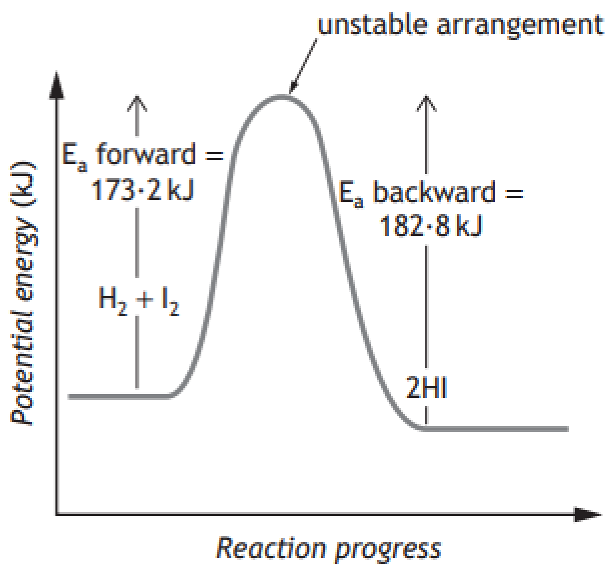
$$C_6H_{12}O_6 + 2Cu^{2+} + H_2O \rightarrow C_6H_{12}O_7 + 2Cu^{+} + 2H^{+}$$

reducing sugar ($C_6H_{12}O_6$); Fehling's solution ($2Cu^{2+}$)

Calculate the concentration, in $mol\,l^{-1}$, of reducing sugars present in the diluted sample of the soft drink. **3**

17.

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



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

18.

(iii) Hydrolysis of fats using hydrochloric acid produces fatty acids. Stearic acid is a fatty acid that can be made from hydrolysis of beef fat. It is a fuel sometimes found in fireworks.

During combustion, stearic acid ($C_{17}H_{35}COOH$) produces 623 kJ of energy **per mole of CO_2 produced.**

$$C_{17}H_{35}COOH \quad + \quad 26O_2 \quad \rightarrow \quad 18CO_2 \quad + \quad 18H_2O$$

mass of
one mole
= 284 g

Calculate the energy released, in kJ, by combustion of 10 grams of stearic acid. **2**

19. (ii) 0·40 g of sodium sulfite, Na_2SO_3, is reacted with 50 cm^3 of dilute hydrochloric acid, concentration 1·0 mol l^{-1}.

$$Na_2SO_3(s) + 2HCl(aq) \rightarrow H_2O(\ell) + 2NaCl(aq) + SO_2(g)$$

mass of
one mole
= 126·1 g

Show, by calculation, that sodium sulfite is the limiting reactant. **2**

20. (b) Another reaction that produces sulfur dioxide gas involves combustion of carbon disulfide in the reaction shown.

$$CS_2(\ell) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)$$

Calculate the enthalpy change, in kJ mol^{-1}, for this reaction using the following information. **2**

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H = -393{\cdot}5\ kJ\,mol^{-1}$$
$$S(s) + O_2(g) \rightarrow SO_2(g) \qquad \Delta H = -296{\cdot}8\ kJ\,mol^{-1}$$
$$C(s) + 2S(s) \rightarrow CS_2(\ell) \qquad \Delta H = +87{\cdot}9\ kJ\,mol^{-1}$$

21. (d) It is recommended an adult female takes in 14·8 mg of iron per day.

100 g of a breakfast cereal contains 12·0 mg of iron.

Calculate the percentage of the recommended daily amount of iron provided for an adult female by a 30 g serving. **2**

22. (ii) Hydrogen peroxide decomposes to form water and oxygen.

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

A dishwasher tablet produces 0·051 g of hydrogen peroxide (mass of one mole = 34 g).

Calculate the volume of oxygen that would be produced when 0·051 g of hydrogen peroxide decomposes. **3**

Take the volume of 1 mole of oxygen gas to be 24 litres.

23. (ii) An equation for the formation of silicon nitride is shown.

$3SiCl_4$	+	$16NH_3$	→	Si_3N_4	+	$12NH_4Cl$
mass of one mole = 170·1 g		mass of one mole = 17·0 g		mass of one mole = 140·3 g		mass of one mole = 53·5 g

Calculate the atom economy for the formation of silicon nitride. **2**

24.

(c) The chemical reaction involved in the experiment is shown.

$C_6H_5COOH(s)$ benzoic acid	+	$CH_3OH(\ell)$	→	$C_6H_5COOCH_3(\ell)$ methyl benzoate
mass of one mole = 122 g		mass of one mole = 32 g		mass of one mole = 136 g

(ii) In a laboratory experiment, a student used 5·0 g of benzoic acid and 2·5 g of methanol to produce methyl benzoate.

Explain why benzoic acid is the limiting reactant.

You must include calculations in your answer. **2**

(iii) The student produced 3·1 g of methyl benzoate from 5·0 g of benzoic acid. Benzoic acid costs £39·80 for 500 g.

Calculate the cost, in £, of the benzoic acid needed to make 100 g of methyl benzoate using the student's method. **2**

25.

(b) (i) Squalene, a triterpene, is included in some flu vaccines to enhance the body's immune response. A single dose of flu vaccine contains 10·69 mg of squalene.

Calculate the mass of squalene required to produce a batch of 500 000 doses of flu vaccine.

Your answer must be given in kg. **2**

26.

(b) Hess's Law can be used to calculate the enthalpy change for reactions that do not normally take place, such as the formation of propyne from its elements.

$$3C(s) + 2H_2(g) \rightarrow C_3H_4(g)$$

Calculate the enthalpy change, in $kJ\,mol^{-1}$, for this reaction using the following information. **2**

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H = -394\,kJ\,mol^{-1}$$

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(\ell) \qquad \Delta H = -286\,kJ\,mol^{-1}$$

$$C_3H_4(g) + 4O_2(g) \rightarrow 3CO_2(g) + 2H_2O(\ell) \qquad \Delta H = -1939\,kJ\,mol^{-1}$$

27.

(c) Propyne, C_3H_4 (1 mole = 40 g), has been suggested as a possible rocket fuel.

(i) The enthalpy of combustion of propyne is $-1939\,kJ\,mol^{-1}$.

Calculate the energy released, in kJ, when 1 kg of propyne is burned completely. **1**

(ii) The mass of air required to burn 1 g of fuel can be calculated using the relationship shown.

Mass of air, in g = 4·3 × mass of oxygen, in g, for complete combustion of 1 g of fuel

Calculate the mass of air, in g, required to burn 1 g of propyne. **2**

$$C_3H_4(g) + 4O_2(g) \rightarrow 3CO_2(g) + 2H_2O(\ell)$$

28.

(ii) An affected animal must be treated with 9 doses of 20% ethanol solution. Each dose contains 5 cm^3 of the ethanol solution for every kilogram body mass of the animal.

Calculate the total volume, in cm^3, of the 20% ethanol solution needed to treat a 3·5 kg animal. **1**

29.

(c) Three samples were prepared as described in **step 2**. Each sample was titrated with 0·0010 mol l^{-1} sodium thiosulfate solution.

The results are shown below.

Sample	*Volume of sodium thiosulfate* (cm^3)
1	10·0
2	9·4
3	9·6

(i) Calculate the average volume, in cm^3, of sodium thiosulfate solution that should be used to determine the number of moles of iodine released. **1**

(ii) Calculate the number of moles of iodine released from 50 cm^3 of the standard salt solution. **2**

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

30.

(b) There are different methods of producing phenol.

(i) In the early 1900s, phenol was produced by the following reaction.

$$C_6H_6 + H_2SO_4 + 2NaOH \rightarrow C_6H_5OH + Na_2SO_3 + 2H_2O$$

benzene	phenol
mass of one mole = 78·0 g	mass of one mole = 94·0 g

Calculate the mass of phenol, in kg, produced from 117 kg of benzene if the percentage yield is 90%. **2**

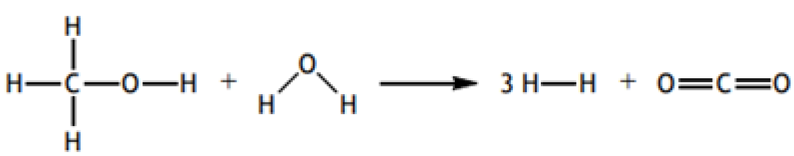
31.

(b) A brand of mouthwash contains the component 1,8-cineole at a concentration of 0·92 mg per cm^3. The cost of 1 kg of 1,8-cineole is £59·10.

Calculate the cost, in pence, of 1,8-cineole that is present in a 500 cm^3 bottle of this brand of mouthwash. **2**

32.

(c) Methanol is used as a source of hydrogen for fuel cells. The industrial process involves the reaction of methanol with steam.



Using bond enthalpy and mean bond enthalpy values from the data booklet, calculate the enthalpy change in kJmol-1 , for this reaction.

33.

Cider is made from apples in a process that involves crushing and pressing the apples, converting the sugars into alcohol, maturing and bottling.

The % mass of alcohol in the cider can be calculated using the formula

$$\%\text{ mass of alcohol} = \frac{\text{mass of alcohol}}{\text{mass of cider}} \times 100$$

A 50·0 cm^3 sample of cider was found to contain 3·05 g of alcohol.
1·0 cm^3 of the cider weighed 1·36 g.

Calculate the % mass of alcohol in the cider. **1**

34.

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.

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

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

35.

(a) (continued)

(iii) Calculate the mass, in g, of carbon dioxide produced by combustion of 200 cm^3 methane in excess oxygen. **2**

Take the volume of 1 mole of methane gas to be 24 litres.

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

GFM = 44·0 g

36.

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

(b) (continued)

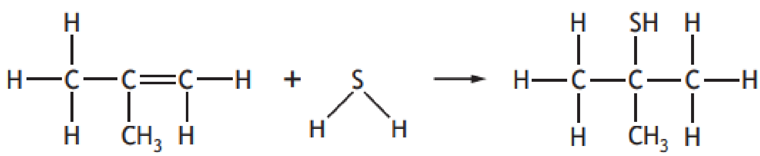
(ii) Calculate the enthalpy of combustion, in $kJ\,mol^{-1}$, for heptane from the experimental results given. **3**

37.

The minimum concentration of ethanethiol in air that can be detected by humans is $2{\cdot}7 \times 10^{-7}$ mg per cm^3 of air.

Calculate the minimum mass of ethanethiol that needs to be present in a room containing 43 900 litres of air in order for it to be detected. **2**

38. 2-methyl-2-propanethiol can be made by the addition reaction shown.



2-methylpropene
GFM = 56·0 g

2-methyl-2-propanethiol
GFM = 90·1 g

A chemist obtained an 84% yield of 2-methyl-2-propanethiol after starting with 30·5 g of 2-methylpropene.

Calculate the mass, in g, of 2-methyl-2-propanethiol made by the chemist. **2**

39.

Bromelain can be purchased as tablets that contain 500 mg of bromelain. The flesh from a pineapple contains 13·2 mg of bromelain per gram.

Calculate the mass, in g, of this pineapple that would be needed to provide 500 mg of bromelain. **1**

40.

(c) Carbon tetrachloride, CCl_4, is prepared by the reaction of chlorine gas, Cl_2, with methane, CH_4.

$$CH_4(g) + 4Cl_2(g) \rightarrow CCl_4(g) + 4HCl(g)$$

Calculate the enthalpy change, in $kJ\,mol^{-1}$, for this reaction using the following information. **2**

$$C(s) + 2H_2(g) \rightarrow CH_4(g) \qquad \Delta H = -75\ kJ\,mol^{-1}$$

$$C(s) + 2Cl_2(g) \rightarrow CCl_4(g) \qquad \Delta H = -98\ kJ\,mol^{-1}$$

$$\tfrac{1}{2}H_2(g) + \tfrac{1}{2}Cl_2(g) \rightarrow HCl(g) \qquad \Delta H = -92\ kJ\,mol^{-1}$$

41.

(iii) 1·393 g of silver chloride precipitate was produced from the magnesium chloride solution.

$$MgCl_2(aq) + 2AgNO_3(aq) \rightarrow 2AgCl(s) + Mg(NO_3)_2(aq)$$

GFM = 95·3 g (for $MgCl_2$) GFM = 143·4 g (for $AgCl$)

Calculate the mass of magnesium chloride, in g, present in the magnesium chloride solution. **2**

The average mass of magnesium chloride in 2·503 g of the original impure sample was calculated to be 2·403 g.

Calculate the % of magnesium chloride present in the original sample. **1**

42.

A prescription for a medication stated that each tablet contained 400mg of lithium carbonate, Li_2CO_3.

Calculate the mass, in mg, of lithium present in 400mg of lithium carbonate.

The mass of one mole of Li_2CO_3 is 73.8g

43.

Ammonia can be prepared by reacting nitrogen with hydrogen.

The equation for this reaction is shown.

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

Using bond enthalpy values from the data booklet, calculate the enthalpy change for this reaction.

44.

The overall equation for the fermentation of glucose is

$C_6H_{12}O_6$	$\rightarrow$	$2C_2H_5OH$	+	$2CO_2$
mass of one mole = 180 g		mass of one mole = 46 g		

Calculate the percentage yield of ethanol if 445 g of ethanol is produced from 1·0 kg of glucose.

45.

The energy density value of a fuel is the energy released when one kilogram of the fuel is burned.

The enthalpy of combustion of ethanol is -1367 kJ mol^{-1}.

Calculate the energy density value, in kJ kg^{-1}, of ethanol.

46.

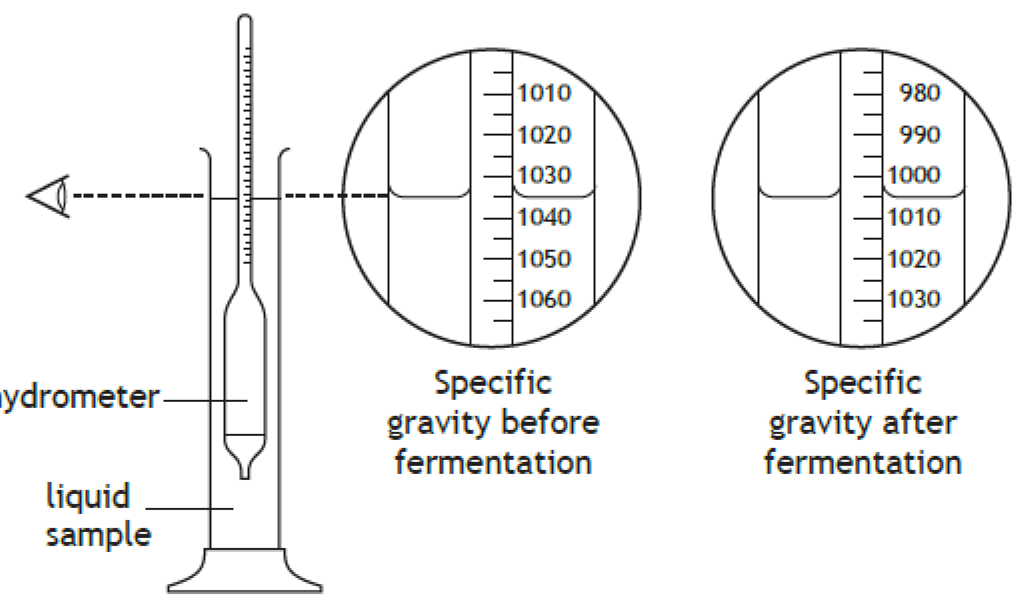
The quantity of alcohol present after a fermentation reaction is called the % alcohol by volume.

This can be calculated from measurements taken using an instrument called a hydrometer. The hydrometer is floated in the liquid sample, before and after fermentation, to measure its specific gravity.

% alcohol by volume = change in specific gravity of liquid x *f*

where *f* is a conversion factor, which varies as shown in the table.

Change in specific gravity of liquid	*f*
Up to 6·9	0·125
7·0 — 10·4	0·126
10·5 — 17·2	0·127
17·3 — 26·1	0·128
26·2 — 36·0	0·129
36·1 — 46·5	0·130
46·6 — 57·1	0·131



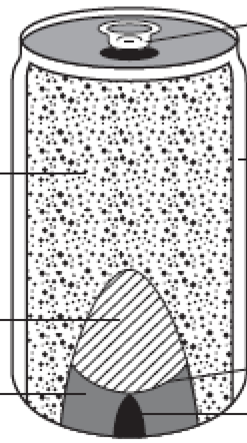
Calculate the % alcohol by volume for this sample.

47. (a)

Self-heating cans may be used to warm drinks such as coffee.

When the button on the can is pushed, a seal is broken, allowing water and calcium oxide to mix and react.

The reaction produces solid calcium hydroxide and releases heat.



The equation for this reaction is:

$$CaO(s) + H_2O(\ell) \rightarrow Ca(OH)_2(s) \qquad \Delta H = -65\ kJ\ mol^{-1}$$

Calculate the mass, in grams, of calcium oxide required to raise the temperature of 210 cm^3 of coffee from 20°C to 70°C.

(b)

If more water is used the calcium hydroxide is produced as a solution instead of as a solid.

The equation for the reaction is:

$$CaO(s) + H_2O(\ell) \rightarrow Ca(OH)_2(aq)$$

Using the following data, calculate the enthalpy change, in kJ mol^{-1}, for this reaction.

$$Ca(s) + \tfrac{1}{2}O_2(g) \rightarrow CaO(s) \qquad \Delta H = -635\ kJ\ mol^{-1}$$

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(\ell) \qquad \Delta H = -286\ kJ\ mol^{-1}$$

$$Ca(s) + O_2(g) + H_2(g) \rightarrow Ca(OH)_2(s) \qquad \Delta H = -986\ kJ\ mol^{-1}$$

$$Ca(OH)_2(s) \rightarrow Ca(OH)_2(aq) \qquad \Delta H = -82\ kJ\ mol^{-1}$$

48.

Sodium benzoate is used in the food industry as a preservative. It can be made by reacting benzoic acid with a concentrated solution of sodium carbonate.

$2C_6H_5COOH$	+	Na_2CO_3	$\rightarrow$	$2C_6H_5COONa$	+	CO_2	+	H_2O
mass of 1 mole = 122 g		mass of 1 mole = 106 g		mass of 1 mole = 144 g		mass of 1 mole = 44 g		mass of 1 mole = 18 g

Calculate the atom economy for the production of sodium benzoate.

49.

A chemist made 300g of sodium benzoate using 350g of benzoic acid and 280g of sodium carbonate.

The cost of the chemicals are shown below.

Benzoic acid	£15.80 for 100g
Sodium carbonate	£3.40 for 1kg

Calculate the cost of the chemicals required to produce 500g of sodium benzoate using this method.

50.

Sherbet contains a mixture of sodium hydrogencarbonate and tartaric acid. The fizzing sensation in the mouth is due to the carbon dioxide produced in the following reaction.

$2NaHCO_3$	+	$C_4H_6O_6$	$\rightarrow$	$Na_2(C_4H_4O_6)$	+ $2H_2O$ + $2CO_2$
sodium hydrogencarbonate		tartaric acid		sodium tartrate	

In an experiment, a student found that adding water to 20 sherbet sweets produced 105 cm^3 of carbon dioxide.

Assuming that sodium hydrogencarbonate is in excess, calculate the average mass of tartaric acid, in grams, in one sweet.

(Take the molar volume of carbon dioxide to be 24 litre mol^{-1}.)

51.

Oxalic acid is found in rhubarb. The number of moles of oxalic acid in a carton of rhubarb juice can be found by titrating samples of the juice with a solution of potassium permanganate, a powerful oxidising agent.

The equation for the overall reaction is:

$$6(COOH)_2(aq) + 6H^+(aq) + 2MnO_4^-(aq) \rightarrow 2Mn^{2+}(aq) + 10CO_2(aq) + 8H_2O(\ell)$$

In an investigation using a 500 cm^3 carton of rhubarb juice, separate 25·0 cm^3 samples were measured out. Three samples were then titrated with 0·040 mol l^{-1} potassium permanganate solution, giving the following results.

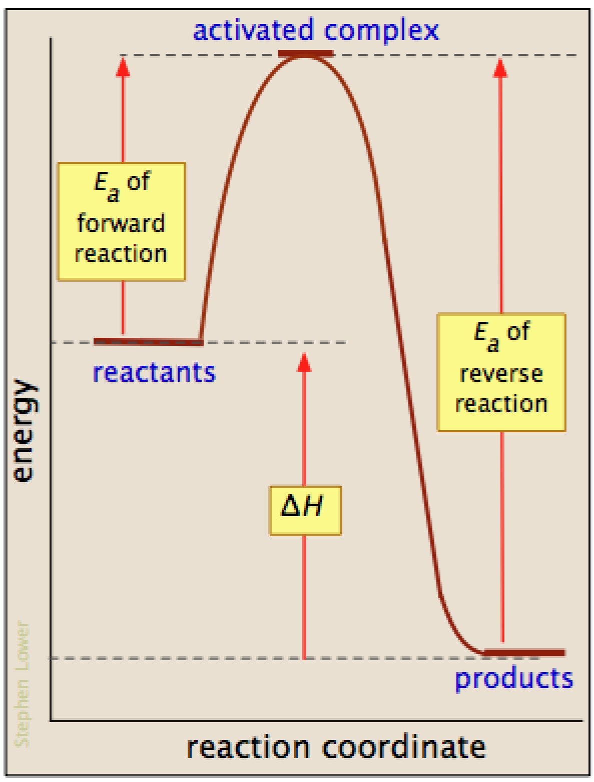
Titration	Volume of potassium permanganate solution used/cm^3
1	27·7
2	26·8
3	27·0

Average volume of potassium permanganate solution used = 26·9cm^3.

Calculate the mass of oxalic acid present in the 500cm^3 carton of rhubarb juice.

Higher Chemistry

Calculations Past Paper Answers



Section 1 Answers

1	D	11	A	21	A
2	B	12	C	22	C
3	C	13	D	23	B
4	B	14	A	24	B
5	A	15	A	25	B
6	D	16	C	26	D
7	C	17	B	27	A
8	B	18	B	28	A
9	A	19	C		
10	B	20	D		

Section 2 Answers

1.

(a)		From graph, rate = 0·022 t = 1/rate = 45 s accept answers in range 45 – 46 s	1	Units not required

2.

(b)	(i)	**1 mark** awarded for correct arithmetical calculation of moles of acid = 0·044 **and** moles alcohol = 0·063 (no penalty for candidates who round to 0·04 and 0·06 etc) **or** working out that 9·25 g cinnamic acid would be needed to react with 2 g methanol or 6·5 g cinnamic acid would react with 1·41 g methanol **1 mark** awarded for statement demonstrating understanding of limiting reactant. eg there are less moles of cinnamic acid therefore it is the limiting reactant **or** 0·0625 moles methanol would require 0·625 moles cinnamic acid **or** methanol is in excess therefore cinnamic acid is the limiting reactant.	2	

(ii) (A)	52% **(2)** Partial Marking 1 mark is given for working out the theoretical yield ie 7·1 g or for working out **both** the moles of reactant used and product formed ie **both** 0·044 moles and 0·023 moles 1 mark is given for calculating the % yield, either using the actual and theoretical masses, or using the actual number of moles of products and actual number of moles of reactant	2	**0 marks awarded for -** 3·7/6·5 × 100 or 56·9%

(ii) (B)	£24·59 Partial marking for **1 mark** Award 1 mark for Evidence for costing to produce of 3·7 g (£0·91) **or** evidence of a calculated mass of cinnamic acid x 14p **or** evidence that 176 g of cinnamic acid required £12·80 would be using 100% yield	**(2)**	**2**	Assume units are £ unless otherwise stated Apply follow through from (b) (ii) (A)

3.

(e)		1·7 g (units not required) partial marking **for 1 mark** for evidence within candidate answer of calculating that 1 mg coumarin is obtained from 0·227 g cinnamon or tolerable daily intake =7·5mg for 75kg individual or evidence of multiplying DTI by 227 (multiplying by 1000 and dividing by 4·4)	**(2)**	**2**	

4.

(a)		118/32 or 3·69 mol CH_3OH 3·69 × 24 = 88·5 litres	**(1)** **(1)**	**2**	Units not required but if given need to be appropriate to the calculation. eg 88 500 cm^3 Follow through applies. eg 1 mark can be awarded if use 64 for GFM giving an answer of 44·25 litres **or** for an arithmetically correct answer derived by multiplying a wrongly calculated number of moles (for which working shown) by 24

5.

(C)	2 concept marks + 1 arithmetic mark Concept marks Demonstration of the correct use of the relationship $E_h = cm\Delta T$ **(1)** eg 4·18 × 0·1 × 23 **or** 9·61 **and** Knowledge that enthalpy of combustion relates to 1 mol **(1)** evidenced by scaling up of energy released Correct arithmetic = −288 kJ mol^{-1} **(1)** Allow follow through of wrong GFM from part (a)	**3**	Maximum of 2 marks can be awarded if negative enthalpy sign is not shown in final answer. If candidate converts 1·07g to 0·033 mol, then candidate answer should be −291 kJ mol^{-1} Units not required

(ii)	0·799 (0·8)	**1**	Units not required

6.

(ii)	10 (Units not required, if given mg per litre, mg l^{-1})	**1**	Accept 0·01 g l^{-1}

7.

(iii)	0·000062 (mol l^{-1}) Partial marks can be awarded using a scheme of two "concept" marks, and one "arithmetic" mark **1 mark** for knowledge of the relationship between moles, concentration and volume. This could be shown by one of the following steps: Calculation of moles thiosulfate solution eg 0·001 × 0·0124 = 0·0000124 **or** calculation of concentration of iodine solution eg 0·0000062/0·1 **or** Insertion of correct pairings of values for concentration and volume in a valid titration formula **1 mark** for knowledge of relationship between moles of thiosulfate and hypochlorite. This could be shown by one of the following steps: Calculation of moles hypochlorite from moles thiosulfate - eg 0·0000124/2 = 0·0000062	**3**	units not required

(b)		**1 mark** correct arithmetic either 44·4 (litres) or 44400 (cm^3) **1 mark** correct units	**2**	

8.

	(ii)	3·7 (volume strength).	1	Ignore any units. 3·7 must clearly be final answer.
c)		8 (s).	1	Accept 7·7 (1/0·13) to 8·3 (1/0·12) or correct answer to 2 decimal places. No units required but no mark is awarded if wrong unit is given. (wrong units would only be penalised once in any paper).

9.

10.

(b)		n =m/gfm =2900/58 =50 **(1 mark)** V = n × Vm = 50 × 24 = 1200 (litres) **(1 mark)** Or by Proportion 58 g ⟶ 24 l **(1 mark)** 2·9 kg ⟶ 24 × 2900/58ℓ = 1200 (ℓ) **(1 mark)**	**2**	Follow through applies in this question. No units required but only one mark can be awarded if wrong unit is given. (wrong units would only be penalised once in any paper) Accept L for ℓ.

11.

<table>
<tr>
<td>(ii)</td>
<td>30 g - units required (2 marks)
Partial marks:
Correctly calculated mass of mushrooms without units,
(1 mark)
Appropriate units (1 mark)

<table>
<tr><th>Mass (1)</th><th>Units (1)</th></tr>
<tr><td>0·03</td><td>kg</td></tr>
<tr><td>30</td><td>g</td></tr>
<tr><td>30000</td><td>mg</td></tr>
</table>
</td>
<td>2</td>
<td>If an incorrect mass is calculated but the units used are appropriate to the calculation then 1 mark would be awarded.

If the candidate has ended the calculation at the lethal dosage then the mark for units can be awarded if the unit is appropriate to the value calculated.

If the candidate's working is unclear in terms of what is being worked out then the mark for units cannot be awarded.</td>
</tr>
</table>

12

(iii)	60·7/61 % **(2 marks)** **1 mark** Calculates theoretical mass = 4·78g **OR** correctly calculates no of moles reactant (0·054) and product (0·033) **1 mark** Calculating % yield using the actual and theoretical masses, or using the actual number of moles of products and actual number of moles of reactant.	**2**	Follow through applies.

13.

(c)		56 or + 56 **(2)** Bond breaking 412 + 412 + 412 + 360 + 463 = 2059 Bond forming 743 + 412 + 412 + 436 = 2003 2059 – 2003 = 56 ($kJ\,mol^{-1}$) A single mark is available if either of the following operations is correctly executed **Either** The five relevant values for the bond enthalpies of the C-H, H-H, C-O, O-H and C=O bonds (or multiples thereof) are retrieved from the data book 412,360,463,743,436 (ignore signs) **OR** If only four values are retrieved, the candidate recognises that bond breaking is endothermic and bond formation is exothermic and correctly manipulates the bond enthalpy values they have used to give their answer.	**2**	–56 would qualify for 1 mark. No units required but only one mark can be awarded for correct answer if wrong unit is given. (wrong units would only be penalised once in any paper). kJ is acceptable in place of $kJ\,mol^{-1}$. If less than four bond enthalpy values are retrieved then no mark can be awarded.

14.

b)	−414 kJ mol^{-1} (no units required) Partial marks Treat as two concepts either would be acceptable for **1 mark** Evidence of understanding of reversal of first equation in order to achieve the target equation. Reversal of both equations would be taken as cancelling **OR** evidence of understanding of multiplying first equation by 2 in order to achieve the target equation.	**2**	No units required but only one mark can be awarded for correct answer if wrong unit is given. (wrong units would only be penalised once in any paper).

15

	(B)	3·43%.	**1**	If a rounded answer is given there must be evidence of the equation being used.
(v)	34·98 (g)/35·0 (g).		**1**	No units required. No mark can be awarded if wrong unit is given. (wrong units would only be penalised once in any paper).

16.

(iv)	0·0099 (mol l^{-1}) **(3 marks)** Partial marks can be awarded using a scheme of two 'concept' marks, and one 'arithmetic' mark. **1 mark** for knowledge of the relationship between moles, concentration and volume. This could be shown by any <u>one</u> of the following steps: • Calculation of number of moles of Cu^{2+} eg 0·025 × 0·0198 = 0·000495 • Calculation of conc of reducing sugars eg 0·0002475 ÷ 0·025 • Insertion of correct pairings of values of conc and volume in titration formula eg $\frac{0\cdot025\times19\cdot8}{n_1}=\frac{C_{RS}\times25\cdot0}{n_2}$ **1 mark** for knowledge of relationship between Cu^{2+} and reducing sugars. This could be shown by any <u>one</u> of the following steps:	**3**	No units required but only two marks can be awarded for correct answer if wrong unit is given. (wrong units would only be penalised once in any paper). 2 concept marks 1 mark for stoichiometric relationship being applied. 1 mark for correctly using n = c × v Candidates require to correctly apply relationship if used twice in their working.

	• Calculation of moles of reducing sugars from moles Cu^{2+} eg 0·000495 ÷ 2 = 0·0002475 • Insertion of correct stoichiometric values in titration formula e.g. $\frac{0 \cdot 025 \times 19 \cdot 8}{2} = \frac{C_{RS} \times 25 \cdot 0}{1}$ **1 mark** is awarded for correct arithmetic throughout the calculation. This mark can only be awarded if both concept marks have been awarded.		In terms of the mark for the stoichiometric relationship, the 1 should be associated with the unknown concentration of the sugar and the 2 with the with concentration of the Fehling's.

17.

(iv) (B)	-9·6 (kJ) If candidate has calculated from graph values **OR** -9 (kJ) If candidate has calculated using bond enthalpies	**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

18.

(iii)	395 or -395 (kJ) Partial marking one mark can be awarded for **the correct application of number of moles of stearic acid** eg 10/284 x 623 or 0·0352 x 623 (=21.94) (=21.93) or 10/284 x 18 or 0·0352 x 18 (=0.634) (=0.634) **OR** **the correct application of the stoichiometry** eg the energy change for 1 mole of stearic acid as 623 x 18 = 11214 (kJ) or 284 g ←→ 623 x 18	**2**	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)

19

(ii)	Calculating that 0·05 moles HCl would require 0·025 moles sodium sulfite and there are only 0.00317 moles of sodium sulfite **OR** Calculating that 0·00317 moles of sodium sulfite would require 0·00634 moles of HCl and there are 0.05 moles of HCl **OR** Calculating that 3·15 g sodium sulfite would be needed to react with 50 cm^3 hydrochloric acid and there are only 0.4 g of sodium sulfite **OR** Calculating that 6·3 cm^3 of (1 M) HCl would be needed to react with 0·4 g of sodium sulfite and there are 50 cm^3 (1M) HCl	**2**	General marking principle (j) applies. Partial marking 1 mark awarded for correct arithmetical calculation of moles of Na_2SO_3 (= 0·00317 mol) **AND** HCl = 0·05 mol) **OR** 1 mark awarded for correct arithmetical calculation of moles of acid (0.05) and correct application of stoichiometry to either reactant. **OR** 1 mark awarded for correct arithmetical calculation of moles of sodium sulfite (0.00317) and correct application of stoichiometry to either reactant.

20

(b)		-1075 (kJ mol^{-1}) Partial marks Treat as two concepts either would be acceptable for 1 mark Evidence of understanding of reversal for third equation only in order to achieve the target equation. Reversal of additional equations would be taken as cancelling **OR** evidence of understanding of multiplying for second equation by 2 in order to achieve the target equation. Multiplication of additional equations would be taken as cancelling.	**2**	If answer given is 1075 or +1075, maximum of 1 mark can be awarded. 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}

21

(d)		24%, 24·3% Partial marks **1 mark** awarded for 30 g would contain 3·6 mg **1 mark** for $\frac{\text{any calculated mass}}{14 \cdot 8} \times 100$	**2**	

22

(ii)	18 cm^3/0·018 litres **with correct unit** **Partial marking** 1 mark can be awarded for two of the three steps shown below correctly calculated: 1. number of moles of H_2O_2 2. mole ratio applied 3. calculated number of moles of O_2 multiplied by 24 (24000) If processed by proportion 68 g ←→ 24 l (24000 cm^3) 1 mark OR 0.051 g ←→ 0.036 l (36 cm^3) 1 mark **1 mark** for correct units.	**3**	If an incorrect volume is calculated but the units of volume used are appropriate to the calculation then 1 mark would be awarded for correct units.

23

$$\%\text{ atom economy} = \frac{\text{Mass of desired product(s)}}{\text{Total mass of reactants}} \times 100$$

$$= \frac{(3 \times 170.1) + (16 \times 17)}{140.3} \times 100$$

$$= \frac{140.3}{782.3} \times 100$$

= 17.93 %

(concept mark applied)

24.

(ii)	Correctly calculates number of moles of: Benzoic acid = 0·041 Methanol = 0·078. **OR** Working out that 1·31 g of methanol would be needed to react with 5 g of benzoic acid. **OR** Working out that 9·53 g of benzoic acid would be needed to react with 2·5 g of methanol. **(1)** Statement demonstrating understanding of limiting reactant eg there are less moles of benzoic acid therefore it is the limiting reactant. **OR** There are more moles of methanol therefore it is in excess. **OR** 0·078 moles of methanol would require 0·078 moles of benzoic acid. **(1)**	**2**	No penalty for candidates who round to 0·04 and 0·08.

(c)	(iii)	(£)12·84 **(2)** Partial Marks Mass benzoic acid = 161·3(g). **OR** Cost to make 3·1g of methyl benzoate = (£) 0·398. **OR** Evidence of a calculated mass of benzoic acid × 7·96 or 8 (p). **(1)**	**2**	Accept 1284 p. Do not accept '1284' on its own; correct units are required. Allow follow through from an initial arithmetic error (for 1 mark). Early rounding of masses correctly followed through is acceptable for award of both marks. Rounding of final answer to the nearest penny is required.

25

(b)	(i)	5·345/5.35/5.3 (kg) **(2)** Partial marking Mass of squalene = 10·69 × 500 000 = 5 345 000 (mg) **(1)** **OR** For incorrectly calculating mass in mg but correctly converting to kg. **(1)** **OR** For incorrectly calculating mass of squalene but correctly multiplying this by 500 000. **(1)** **OR** Conversion of 10·69 mg to kg ie $10·69 \times 10^{-6}$.	**2**	Answer must be in kg to access both marks, 5345 g would be awarded 1 mark only.

26.

(b)		(+) 185 (kJ mol^{-1}) [(-1182) + (-572) + (+1939)] = (+) 185 (kJ mol^{-1}) Partial marks Treat as two concepts. Either would be acceptable for 1 mark. Evidence of understanding of reversal of third enthalpy value ie +1939 or 1939 must be seen. The other two enthalpy values (regardless of value) **must** be negative, or this partial mark cannot be awarded. **OR** Evidence of understanding of multiplying the first enthalpy value by 3 and the second enthalpy value by 2. Ignore the enthalpy signs associated with these numbers ie any combination of 3 (±394) **and** 2 (±286)	**2**	If answer given is −185, maximum of 1 mark can be awarded. 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). Only one concept mark can be awarded if the final answer is incorrect.

27

(c)	(i)	48475 (kJ)	**1**	−48475 (kJ) is accepted. No units required. Zero marks can be awarded for the correct answer if wrong unit is given. kJ mol^{-1} is not an acceptable unit in this question. (Wrong units would only be penalised once in any paper).
	(ii)	13·76/13·8/14 (g) Partial mark 1 mark Mass of oxygen required = 3·2 (g) **OR** 550·4 (g)	**2**	Accept correctly calculated answer in mg or kg, providing units are shown with answer. This is obtained from an incorrect mass of oxygen (4 × 32 = 128) being calculated.

28

(ii)	157·5(cm^3)	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).

29

(c)	(i)	9·5(cm^3)	1	No units required but no mark is awarded if wrong unit is given. (Wrong units would only be penalised once in any paper).
	(ii)	$4{\cdot}75 \times 10^{-6}$ moles Partial mark for correct use of mole ratio. **OR** Determination of number of moles without using the mole ratio.	2	Allow follow through from c (i).

30

(b)	(i)	126·9/127(kg) Partial mark either for: Calculation of the theoretical yield 141 (no unit required) **(1)** **OR** for correctly calculating 90% of an incorrectly calculated theoretical yield. **(1)**	2	No units required but a maximum of 1 mark is awarded if wrong unit is given. (Wrong units would only be penalised once in any paper). Early rounding correctly followed through is acceptable for award of both marks. Accept correctly calculated answer in g, providing units are shown with answer, eg 126900 g.

31.

(b)		2·7p/ 3p Partial marking 1 mark can be awarded for Evidence of scaling up to $500cm^3$ eg 460mg of 1,8-cineole **OR** Evidence for determining a correct cost for a calculated mass of 1,8-cineole eg 0·92mg costs 0.00544 pence	**2**	

32

	(ii)	Answer = +191 kJ mol^{-1} **(2)** Partial mark 1 mark Evidence of the use of **all** the correct bond enthalpies. **(1)** (412, 360, 463, 436, 743) **or** Correct use of incorrect bond enthalpy values	**2**	Positive sign does not need to be given in answer

33.

(ii)	4·5/4·49/4·485 (%)	**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).

34.

(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.

35.

0·367/0·37/0·4 (g) **(2)** Partial marking $n = V/V_m$ = 0·2/24 = 0·008333….**(1)** an incorrectly calculated number of moles **based on gas volume** x 44 **(1)** or by proportion 24 l → 44 g **(1)** Follow through from incorrect multiples of 24 l **or** 44 g **(1)**	**2**	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). Working must be shown for incorrectly calculated number of moles based on gas volume.

36.

(ii)	-3496 (kJ mol^{-1}) (3 marks) **If final answer is wrong a maximum of 2 marks for the following concepts may be awarded** **1 mark** for a demonstration of the correct use of the relationship $E_h = cm\Delta T$ as shown by (4·18 x (an order of magnitude of 4) x 23) (ignore units for this mark). **1 mark** for evidence of the knowledge that enthalpy of combustion relates to 1 mole, evidenced by the scaling up of a calculated value of energy released.	**3**	An answer of +3496 would gain 2 marks. No units required. A maximum of 2 marks 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).

37.

11·853/11·85/11·9/12 mg - units required **(2)** Correctly calculated mass of ethanethiol without units **(1)** Appropriate units **(1)**	**2**	If an incorrect mass is calculated but the units used are appropriate to the calculation then 1 mark would be awarded. If the candidate's working is unclear then the mark for units cannot be awarded.

Mass (1)	Units (1)
12	mg
0·012	g
$1{\cdot}2 \times 10^{-5}$	kg

38.

(ii) B	41·2 (g) **(2)** **OR** correct calculation of Theoretical mass = 49·07 (g) **(1)** Allow follow on from incorrect calculation of theoretical mass for **1 mark**	**2**	Award 0 marks if candidate gives 25·6 grams (84% of reactant mass)

39.

(ii)	38/37·9/37·88 (g)	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).

40.

	-391 (kJ mol^{-1}) **(2 marks)** Partial marks Treat as two concepts. Either would be acceptable for **1 mark.** Evidence of understanding of reversal of first enthalpy value. ie +75 must be seen. The other two enthalpy values (regardless of value) **must** be negative, or this partial mark cannot be awarded. **OR** Evidence of understanding of multiplying the third enthalpy value by 4(± 92). **OR** ± 368 Multiplication of any other enthalpy value by any factor is taken as cancelling of this partial mark.	2	**Only one concept mark can be awarded if the final answer is incorrect.** If answer given is +391, maximum of 1 mark can be awarded. 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).

41.

(iii)	0·463/0·46/0·5 (g) Partial marking (**1 mark**) **1 mark** for knowledge of relationship between moles of silver chloride and magnesium chloride. This could be shown by a calculated number of moles of silver chloride correctly divided by 2 **OR** Incorrect mole ratio used but the relationship between moles and mass used correctly twice **OR** by proportion 95·3 ↔ 286·8 (2 x 143·4) **OR** Mole ratio not applied correctly but proportion used correctly	2	No units required. Only 1 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).
(c)	96/96·0 (%)	1	

42.

75 (mg)

$2 \times 6.9 = 13.8$

$\frac{13.8}{73.8} \times 400 = 75$

43.

$-75 kJmol^{-1}$

1 mark for any of the following:

$945, 3 \times 436, 3 \times 388, 6 \times 388, 2328, 2253$

Bonds broken =

(NN) = 945

$3(HH) = 3 \times 346 = 1308$

Total = +2253.

Bonds made = $2 \times (3 \times NH) = 6 \times 388 = -2328$

$2253 - 2328 = -75$

44.

87%

Partial marks can be awarded using a scheme of two "concept" marks and one "arithmetic" mark.

1 mark is given for candidate showing understanding of the concept of an actual yield divided by a theoretical yield either using masses or moles of reactant and product.

1 mark is given for candidate displaying understanding of the 1:2 stoichiometry in the reaction.

1 mark is awarded for correct arithmetic throughout the calculation. This mark can only be awarded if both concept marks have been awarded.

180g ➠ 2×46g

46180 = 0.511

1000g ➠ 511g (theoretical)

$\times 100$

$\frac{445}{511} \times 100 = 87\%$

45. 29717 or roundings

(no units required and ignore sign if included)

−1367 kJ mol^{-1}
1 mol of ethanol = 46g i.e.
46g ➡ −1367 kJ
1g ➡ 29.72 kJ
1000g ➡ 29717kJ kg^{-1}

46.

3·87 (%)

For 1 mark candidate must have either 1035−1005 or 30 or 0·129

Change in SG = 1035−1005 = 30
So, f = 0.129
30 × 0.129 = 3.87

47. (a)

37·7 g
(no units required — ignore incorrect units)

Partial marks can be awarded using a scheme of two "concept" marks and one "arithmetic" mark.

1 mark for demonstration of use of the relationship $E_h = cm\Delta T$ this mark is for the concept, do not penalise for incorrect units or incorrect arithmetic.

The value of 43·89 (kJ) would automatically gain this mark.

1 mark for demonstration of knowledge that the enthalpy value provided relates to 1 mole of calcium oxide reacting with water.

This mark could be awarded if the candidate is seen to be working out the number of moles of calcium oxide required (0·67) or if the candidate's working shows a proportion calculation involving use of the gfm for calcium oxide (56).

1 mark is awarded for correct arithmetic throughout the calculation. This mark can only be awarded if both concept marks have been awarded.

$E_h = cm\Delta T$
= 4.18 × 0.21 × 50 = 43.89 kJ
65 kJ ➡ 1 mol CaO
65kJ ➡ 56g
1kJ ➡ 0.861 g
43.89kJ ➡ 37.81g

47. (b)

− 147 kJ mol^{-1}

partial marks

1 mark is awarded for 2 out of the four following numbers being shown
+ 635 + 286 − 986 − 82

48.

82·3 (82%)

1 mark: Concept atom economy ie desired product mass over reactant masses (to be exemplified at central marking)

1 mark: Correct arithmetic

$$\frac{2 \times 144}{(2 \times 122) + 106} \times 100 = 82.3$$

Maximum mark:

49.

£93.75

Partial marks:
583g **AND** 467g (1 mark)
£92.16 **OR** £1.59 (1 mark)

Benzoic acid:
300g requires 350g

$$\frac{350}{300} = 1.167$$

500g requires 1.167 × 500 = 583.33g of benzoic acid.
100g costs £15.80

$$\frac{15.80}{100} = £0.158$$

583.33g costs £92.17

Sodium carbonate:
300g requires 280g

$$\frac{280}{300} = 0.933$$

500g requires 0.933 × 500 = 466.67 g
1000g costs £3.40

$$\frac{3.40}{1000} = £0.0034$$

466.67g costs £1.59

50.

0.0165 g

1 mark for stoichiometric understanding of $NaHCO_3$ and CO_2

1 mark for showing conversion to of grams and litres.

1 mark is awarded for correct arithmetic calculation of mass equivalent to 105cm^3

$\frac{105}{24000} = 0.004375$

$\frac{0.004375}{2} = 0.0022$

Mass tartaric = 0.0022 × 150 = 0.33

$\frac{0.33}{20} = 0.0164$g

51.

5.81 (g) – 4 marks

Correct use of 6:2 ratio to calculate moles of oxalic acid (1 mark)

Correct scaling from 25 ➠ 500 (1 mark)

Gfm of oxalic acid = 90 (1 mark)

Calculation of a mass of oxalic acid (1 mark)

Moles permanganate = $0.04 \times \frac{26.9}{1000} = 0.0010$

Moles oxalic = $\frac{0.0010}{2} \times 6 = 0.0032$ (for 25cm^3)

Moles for 500cm^3 = 0.065

Mass oxalic = 0.065 × 90 = 5.81g

Mass = 0.0538 × 90 = 4.84g