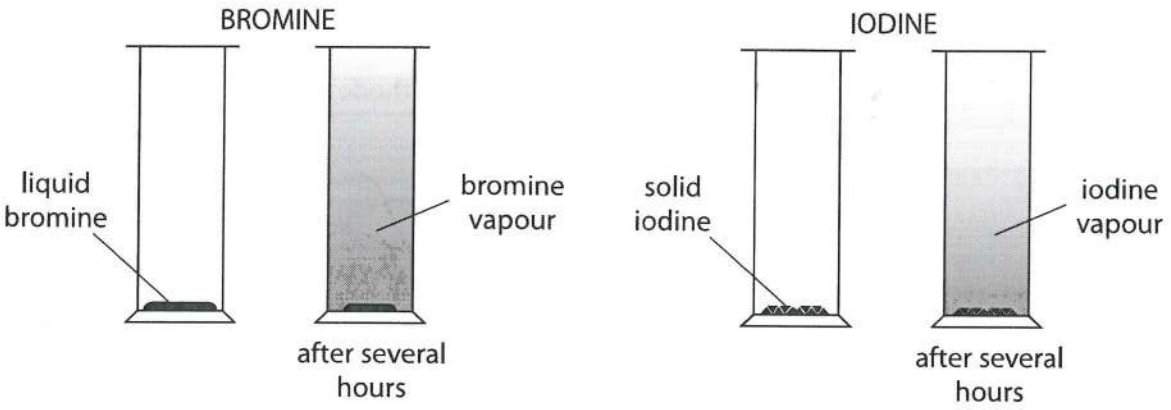
Answer ALL questions. Write your answers in the spaces provided.

1 A few drops of liquid bromine are placed at the bottom of a gas jar.
A few crystals of solid iodine are placed in the bottom of a different gas jar.
The open ends of the gas jars are covered with lids.
The gas jars are left for several hours under the same conditions.

The diagram shows the gas jars just after the bromine and iodine are added, and after several hours.



(a) State the colour of bromine vapour and of iodine vapour.

(2)

bromine vapour brown

iodine vapour purple

(b) (i) The diagram shows that the molecules of bromine and iodine have spread out in the gas jars.

Name this process.

(1)

diffusion

(ii) The liquid bromine evaporates before this process occurs.

The chemical equation for this change is

$$Br_2(l) \rightarrow Br_2(g)$$

The change involving iodine is called sublimation.

Write a chemical equation, including state symbols, for the sublimation of iodine.

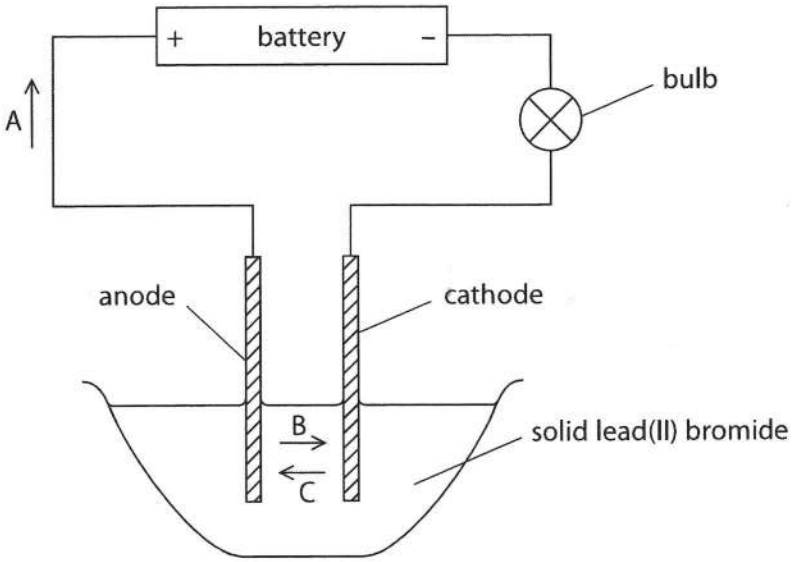
(1)

$I_2(s) \rightarrow I_2(g)$

(Total for Question 1 = 4 marks)

2 This apparatus is used to electrolyse the ionic compound lead(II) bromide, $PbBr_2$

Lead(II) bromide is insoluble in water.



(a) When the apparatus is set up as shown, electrolysis does not occur.

State what must be done for electrolysis to occur.

(1)

melt the lead (II) bromide

(b) When the necessary change is made and electrolysis occurs, particles A, B and C move in the directions shown by the arrows.

Identify each of the particles A, B and C.

(3)

A electrons

B lead (II) ions

C bromide ions

(c) (i) Write an ionic half-equation for the reaction at the cathode.

(1)

$Pb^{2+} + 2e^- \rightarrow Pb$

(ii) State why the reaction at the cathode is described as reduction.

(1)

lead ions are gaining electrons

(Total for Question 2 = 6 marks)

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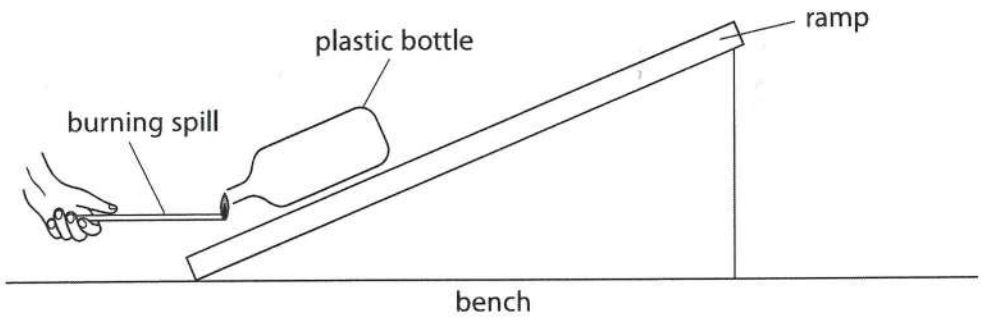
3 Methane reacts with oxygen in an exothermic reaction.

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

If a burning spill is placed near a mixture of methane and oxygen there is an explosion.

- A teacher fills a plastic bottle with a mixture of methane and oxygen.
- He places the bottle on a sloping ramp and then puts a burning spill near to the open end of the bottle.



- The explosion causes the bottle to move up the ramp and shoot off the end.
- The teacher measures the distance the bottle travels before it hits the bench.

The teacher wants to find the volumes of methane and oxygen that will send the bottle the greatest distance. He repeats the experiment using the same bottle, but changing the volumes of methane and oxygen.

The volume of the bottle is 1000 cm^3.

The table shows his results.

Volume of methane used in cm^3	Volume of oxygen used in cm^3	Distance travelled by bottle in m
0	1000	0.00
100	900	2.50
200	800	5.00
600	400	5.00
800	200	2.50
1000	0	0.00

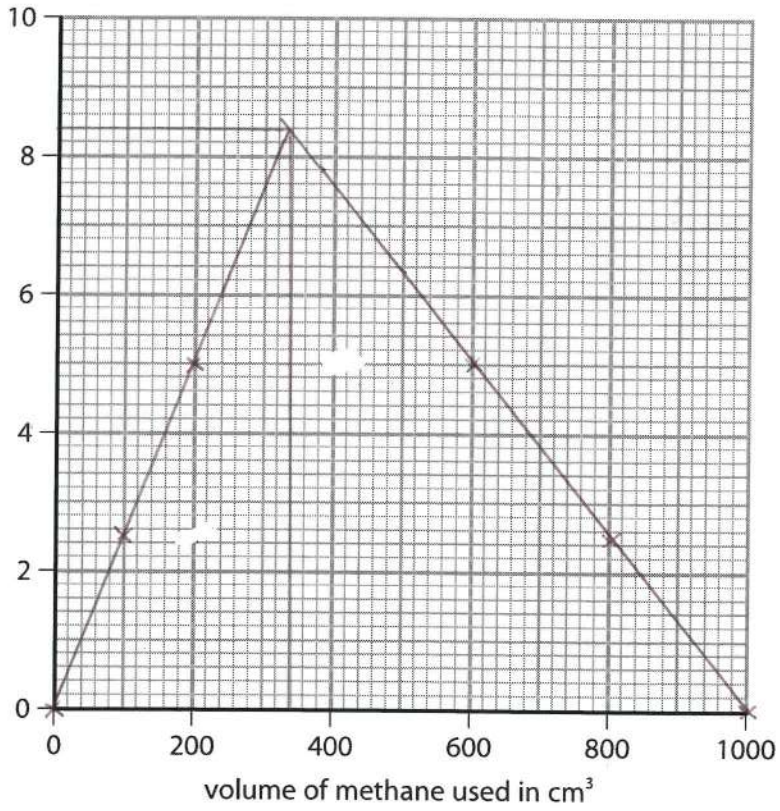
(a) Complete the table to show the volume of oxygen used in each experiment.

(1)

(b) (i) Plot the teacher's results on the grid.

Draw a straight line of best fit through the first three points, and another straight line of best fit through the last three points. Make sure that the two lines cross.

(3)



(ii) Use the graph to determine the volume of methane needed to produce the greatest distance travelled by the bottle.

Show on the graph how you obtained your answer.

(2)

volume = 330 cm³

(c) Suggest why the teacher should obtain more results between 200 cm³ and 600 cm³ of methane used.

(1)

To get a better idea of where the two lines actually cross over.

(Total for Question 3 = 7 marks)

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4 This question is about ethanoic acid.

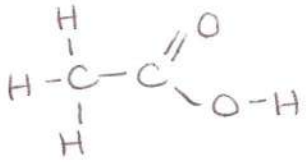
(a) What is the structural formula for ethanoic acid?

(1)

☐ **A** CH_3CH_2OH

☐ **B** $HCOOCH_3$

☒ **C** CH_3COOH



☐ **D** CH_3OCH_3

(b) An aqueous solution of ethanoic acid is weakly acidic.

What is a possible value for the pH of an aqueous solution of ethanoic acid?

(1)

☐ **A** 0

☒ **B** 5

☐ **C** 8

☐ **D** 14

(c) Effervescence occurs when an aqueous solution of ethanoic acid is added to solid sodium carbonate.

Which gas causes the effervescence?

(1)

☐ **A** ammonia

☒ **B** carbon dioxide

☐ **C** hydrogen

☐ **D** oxygen

(d) Ethanoic acid reacts with ethanol to form an ester.

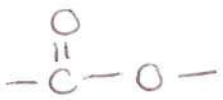
Give the name of this ester.

(1)

emyl ethanoate

(e) Draw the displayed formula of the functional group in esters.

(1)



(Total for Question 4 = 5 marks)

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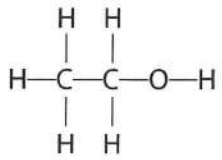
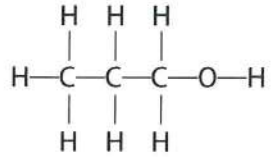
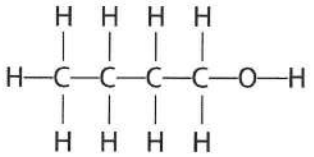
5 The table gives some information about the first four members of the homologous series of alcohols.

Name of alcohol	Molecular formula	Structural formula	Displayed formula
methanol	CH_4O	CH_3OH	methanol
ethanol	C_2H_6O	CH_3CH_2OH	
propanol	C_3H_8O	$CH_3CH_2CH_2OH$	
butanol	$C_4H_{10}O$	$CH_3CH_2CH_2CH_2OH$	

(a) Complete the table by giving the missing information.

(3)

(b) Ethanol is manufactured in industry by reacting ethene with steam in the presence of a catalyst.

(i) Give the name of the catalyst used in this process.

(1)

phosphoric acid

(ii) State the temperature and pressure used in this process.

(2)

temperature 300 °C

pressure 65 atm

(Total for Question 5 = 6 marks)

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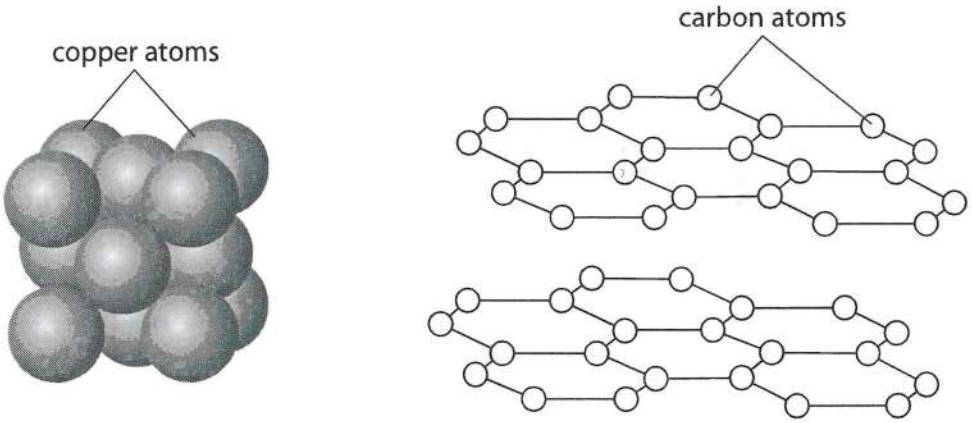
6 Copper is a metal.

Graphite is a form of carbon and is a non-metal.

Both copper and graphite have high melting points and both conduct electricity.

The diagram shows the arrangement of the atoms in copper and in graphite.



(a) Describe, in terms of electrostatic attractions, the bonding between the atoms in copper and the bonding between the atoms in graphite.

(2)

copper electrostatic attraction between nuclei of atoms and the delocalised electrons

graphite electrostatic attraction between nuclei and the shared pair of electrons

(b) Explain how copper conducts electricity.

(2)

- has delocalised electrons
- which are free to move

(c) Explain why graphite has a high melting point.

(2)

- has strong covalent bonds
- which require a lot of energy to overcome

(Total for Question 6 = 6 marks)

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7 The most common ore of chromium is chromite.

Chromite contains iron, chromium and oxygen in these proportions by mass.

Fe 25.0% Cr 46.4% O 28.6%

(a) Show, by calculation, that the empirical formula of chromite is $FeCr_2O_4$
[The relative atomic masses are Fe = 56 Cr = 52 O = 16]

(3)

Fe	Cr	O
$\frac{25}{56}$	$\frac{46.4}{52}$	$\frac{28.6}{16}$
$\frac{0.446}{0.446}$	$\frac{0.892}{0.446}$	$\frac{1.79}{0.446}$
1	2	4

(b) The stages involved in the extraction of chromium from chromite are

Stage 1 Chromite is reacted with potassium hydroxide, KOH, and oxygen to form potassium dichromate(VI), $K_2Cr_2O_7$

Stage 2 Potassium dichromate(VI) is heated with carbon to form chromium(III) oxide, Cr_2O_3, potassium carbonate, K_2CO_3, and carbon monoxide.

Stage 3 Chromium(III) oxide is heated with aluminium.

$$Cr_2O_3 + 2Al \rightarrow 2Cr + Al_2O_3$$

(i) Complete the equation for the reaction in stage 1.

(1)

$$\ldots FeCr_2O_4 + \underline{2}\,KOH + \underline{1\tfrac{1}{2}}\,O_2 \rightarrow \ldots FeO + \ldots K_2Cr_2O_7 + \ldots H_2O$$

(ii) Write a chemical equation for the reaction in stage 2.

(1)

$K_2Cr_2O_7 + 2C \rightarrow Cr_2O_3 + K_2CO_3 + CO$

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(iii) Explain which element is reduced in the reaction in stage 3.

(2)

- chromium
- it has lost oxygen

(iv) Explain what the reaction in stage 3 suggests about the reactivity of aluminium compared to the reactivity of chromium.

(2)

- aluminium is more reactive
- because aluminium has displaced chromium from its oxide

(c) Ethanol is oxidised to form compound X when it is heated with potassium dichromate(VI) in dilute sulfuric acid.

(i) State the colour change observed in the potassium dichromate(VI) during this reaction.

(1)

from orange to green

(ii) Give the name of compound X.

(1)

ethanoic acid

(Total for Question 7 = 11 marks)

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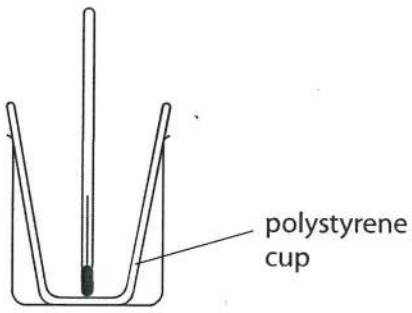
8 A student uses this apparatus to measure the temperature change when solid sodium hydrogencarbonate is added to an aqueous solution of citric acid.



This is her method.

- use a measuring cylinder to add 35 cm^3 of 1.00 mol/dm^3 citric acid to the polystyrene cup and record the initial temperature of the solution
- add 7 g (an excess) of solid sodium hydrogencarbonate and stir the mixture
- record the lowest temperature reached

The table shows her results.

Initial temperature of the solution in °C	21.0
Lowest temperature reached by the mixture in °C	4.1

(a) Show that the heat energy change (Q) during this reaction is about 2500 J.
[assume 1 cm^3 of solution has a mass of 1 g and c for the solution = 4.18 J/g/°C]

(3)

$Q = mc\Delta T$

$= 35 \times 4.18 \times (21 - 4.1)$

$= 35 \times 4.18 \times 16.9$

$= 2472$ J

~ 2500

$Q =$ 2472 J

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(b) Calculate the enthalpy change for the reaction, ΔH, in kilojoules per mole of citric acid.

Include a sign in your answer.

(3)

$$\Delta H = \frac{Q}{\text{moles}}$$

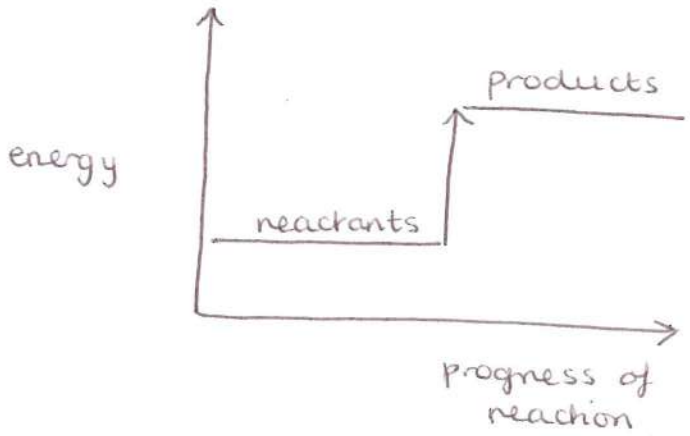
$$\text{mol (citric acid)} = 0.035 \times 1$$
$$= 0.035 \text{ mol}$$

$$\Delta H = \frac{2472}{0.035} = +70.6$$

$\Delta H =$ +70.6 kJ/mol

(c) Draw an energy level diagram for the reaction between citric acid and sodium hydrogencarbonate.

(3)



(d) Explain why it is better to use a burette rather than a measuring cylinder to measure the volume of aqueous citric acid.

(2)

- burette has been calibrated more accurately
- therefore, the volume of acid measured is likely to be more accurate

(Total for Question 8 = 11 marks)

9 A student is asked to find the concentration of a solution of sulfuric acid.

He plans to titrate a known volume of sulfuric acid in a conical flask with 0.400 mol/dm^3 sodium hydroxide solution using phenolphthalein as an indicator.

(a) Describe how to do this titration.
Assume all glassware is clean and does not need rinsing.

(5)

- place sodium hydroxide in burette and take initial reading
- use a pipette to place 25 cm^3 of sulfuric acid in conical flask and add a few drops of phenol phthalein
- add sodium hydroxide until phenolphthalein turns pink
- take final reading of burette and calculate volume of alkali added
- repeat to obtain concordant results

(b) (i) In this titration, 23.85 cm^3 of the sodium hydroxide solution are needed to neutralise the sulfuric acid.

Calculate the amount, in moles, of NaOH in 23.85 cm^3 of the sodium hydroxide solution.

(2)

mol (NaOH) = 0.02385 × 0.4

= 0.00954 mol

amount = 0.00954 mol

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(ii) The student used 25.0 cm^3 of sulfuric acid in his titration.

The equation for the reaction is

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

Calculate the concentration, in mol/dm^3, of the sulfuric acid.

(3)

$$\text{mol } (H_2SO_4) = \frac{0.00954}{2} = 0.00477$$

$$\text{conc } (H_2SO_4) = \frac{0.00477 \times 1000}{25}$$

concentration = 0.191 mol/dm^3

(c) A solution of sodium sulfate is formed by neutralising some dilute sulfuric acid with aqueous sodium hydroxide.

Describe, using the method of crystallisation, how you would obtain a pure, dry sample of sodium sulfate from this solution.

(4)

- heat / boil to evaporate some of the water
- leave solution to cool so that crystals form
- filter to obtain crystals
- dry the crystals by placing in warm oven

(Total for Question 9 = 14 marks)

TOTAL FOR PAPER = 70 MARKS

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