

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

- 1 The table shows some properties of four substances, P, Q, R and S.

Substance	Melting point /°C	Boiling point /°C	Conducts electricity when	
			solid	liquid
P	3410	5930	yes	yes
Q	734	1435	no	yes
R	−95	69	no	no
S	2507	3900	no	no

Use the information in the table to answer the following questions.
You may use each letter once, more than once or not at all.

Choose a substance that:

- (a) is a solid at 3000 °C.

(1)

- ☒ A substance P
☐ B substance Q
☐ C substance R
☐ D substance S

- (b) is a liquid at 25 °C.

(1)

- ☐ A substance P
☐ B substance Q
☒ C substance R
☐ D substance S

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(c) is an ionic compound.

(1)

☐ A substance P

☒ B substance Q

☐ C substance R

☐ D substance S

(d) is a metal.

(1)

☒ A substance P

☐ B substance Q

☐ C substance R

☐ D substance S

(Total for Question 1 = 4 marks)

2 This is a method used to measure the solubility of a solid in water:

- add an excess of solid to some water in a boiling tube and stir
- measure the temperature of the saturated solution formed
- weigh an empty evaporating basin
- pour some of the saturated solution into the evaporating basin
- weigh the basin and contents
- heat the evaporating basin to remove all of the water
- weigh the evaporating basin and remaining solid.

(a) The table shows the results of an experiment using this method.

mass of evaporating basin / g	89.6
mass of evaporating basin + saturated solution / g	115.8
mass of evaporating basin + solid / g	94.9

Calculate the mass of solid obtained and the mass of water removed.

(2)

mass of solid = 5.3 g

mass of water = 20.9 g

(b) In another experiment, at a different temperature, the mass of solid obtained is 10.5 g and the mass of water removed is 16.8 g.

Calculate the solubility of the solid, in g per 100 g of water, at this temperature.

(2)

$$\frac{10.5}{16.8} \times 100 = 62.5$$

solubility = 62.5 g per 100 g of water

- (c) If the evaporating basin is heated too strongly some of the solid decomposes to form a gas.

Explain how this strong heating would affect the value of the calculated solubility of the solid.

(3)

- gas will escape
- mass of solid remaining would be less than it should be
- value of calculated solubility of solid would be lower than it should be

(Total for Question 2 = 7 marks)

- 3 Astatine, bromine, chlorine, fluorine and iodine are all halogens. They are found in Group 7 of the Periodic Table.

(a) Predict which halogen has the lightest colour.

(1)

fluorine

(b) Name a halogen that is a solid at room temperature.

(1)

iodine

- (c) Bromine can be obtained from the bromide ions in sea water. Chlorine is bubbled into sea water. The chlorine oxidises the bromide ions to bromine atoms. The bromine atoms then form bromine molecules.

(i) Complete the equation to show how bromine **atoms** are formed from bromide ions.

(1)



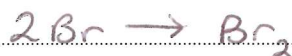
(ii) State why this reaction is described as the oxidation of bromide ions.

(1)

Bromide ions are losing electrons

(iii) Write an equation to show how bromine atoms form bromine molecules.

(1)

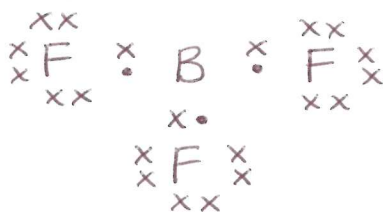


(d) Boron and fluorine form a covalent compound that has the molecular formula BF_3

Draw a dot-and-cross diagram to show the arrangement of the outer electrons in a molecule of BF_3

Use crosses (X) to represent the outer electrons of boron. Use dots (•) to represent the outer electrons of fluorine.

(2)



(Total for Question 3 = 7 marks)

4 A technician finds a white solid in an unlabelled beaker.

She knows that the solid is one of the following substances:

- potassium chloride
- potassium sulfate
- sodium chloride
- sodium sulfate.

Describe how the technician can use chemical tests to identify the solid in the beaker.

(6)

Test for cation:

- carry out a flame test
- If flame is yellow, cation is sodium
- If flame is lilac, cation is potassium

Test for anion:

- Dissolve solid in water
- Add silver nitrate (aq)
- chloride ions would form a white precipitate

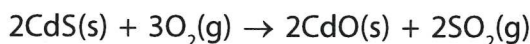
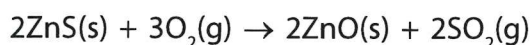
(Total for Question 4 = 6 marks)

5 Zinc metal is obtained from sulfide ores.

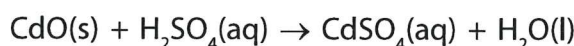
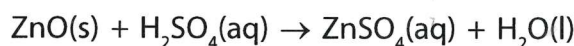
The most common ore of zinc is sphalerite, which contains zinc sulfide (ZnS) and a small amount of cadmium sulfide (CdS).

The stages involved in the extraction of zinc from sphalerite are:

Stage 1 Sphalerite is strongly heated in air.



Stage 2 The mixture of oxides is reacted with sulfuric acid.



Stage 3 Zinc dust is added to the solution containing zinc sulfate and cadmium sulfate to remove the cadmium ions.



Stage 4 The solid cadmium is filtered off and the pure zinc sulfate solution is electrolysed.

(a) State how the reaction in stage 3 shows that zinc is more reactive than cadmium.

(1)

Zinc displaces cadmium

(b) (i) During the electrolysis in stage 4, zinc is deposited on the cathode.

Write an ionic half-equation for the reaction that occurs.

(1)



(ii) Complete the ionic half-equation for the reaction occurring at the anode.



(1)

(iii) Explain how the pH of the solution surrounding the anode changes during the electrolysis.

(2)

• pH decreases

• as hydrogen ions are produced during the reaction

(c) Zinc is mixed with copper to make the alloy brass.

Explain why brass is harder than pure copper.

(3)

- zinc and copper ions are of different sizes
- This disrupts the structure of copper ions
- So, more difficult for the layers of ions to slide over each other

(Total for Question 5 = 8 marks)

- 6 The mineral nesquehonite is a form of hydrated magnesium carbonate.

The formula, $\text{MgCO}_3 \cdot x\text{H}_2\text{O}$, shows that nesquehonite contains water of crystallisation.

When a sample of nesquehonite is heated gently, the water of crystallisation is given off and anhydrous magnesium carbonate is left.

Six students are each given a sample of nesquehonite of mass 6.1 g. The students heat their samples for different times. The samples are then allowed to cool before being reweighed.

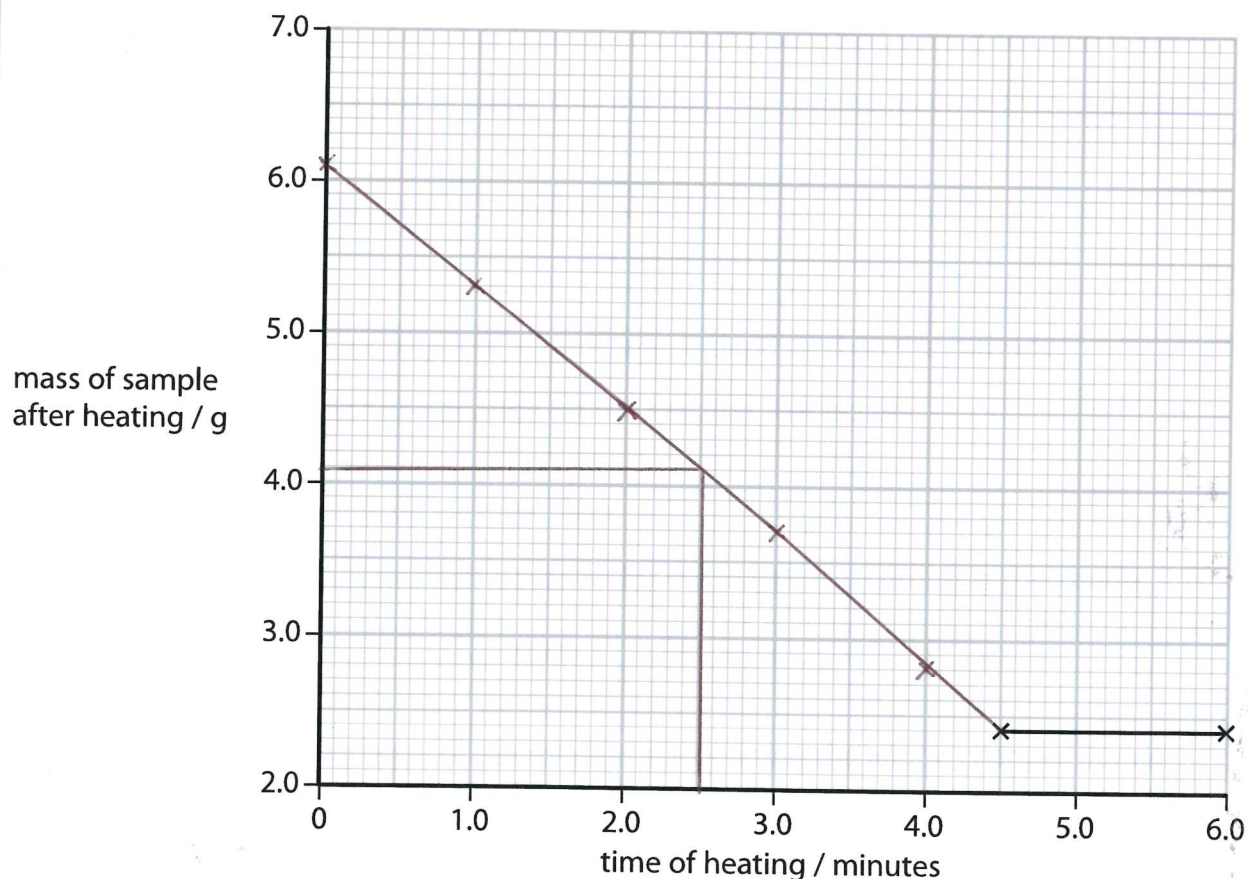
The table shows their results.

time of heating / minutes	0	1.0	2.0	3.0	4.0	4.5	6.0
mass of sample after heating / g	6.1	5.3	4.5	3.7	2.8	2.4	2.4

- (a) Plot these results on the grid provided. The last two points have been plotted for you.

Draw a straight line of best fit for the points you have plotted.

(2)



- (b) Predict the mass of sample remaining after heating for 2.5 minutes.
Show on the graph how you obtain your answer.

(2)

mass after 2.5 minutes = 4.1 g

- (c) State why the last two masses in the table are exactly the same.

(1)

All of the water has been removed

- (d) A sample of nesquehonite contains 1.68 g of MgCO_3 and 1.08 g of H_2O .
Calculate the value of x in the formula $\text{MgCO}_3 \cdot x\text{H}_2\text{O}$
[M_r of $\text{MgCO}_3 = 84$; M_r of $\text{H}_2\text{O} = 18$]

(3)

MgCO_3 1.68 84 0.02	H_2O 1.08 18 0.06	$\frac{0.06}{0.02} = 3$
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$x = \underline{3}$

- (e) When anhydrous magnesium carbonate is heated strongly, it decomposes.
The equation for the reaction is:



Calculate the volume of carbon dioxide formed in cm^3 , at rtp, when 4.2 g of anhydrous magnesium carbonate are completely decomposed.

[M_r of $\text{MgCO}_3 = 84$]

[Assume that the molar volume at rtp of carbon dioxide is 24 dm^3]

(3)

$$\text{mol} = \frac{\text{mass}}{M_r}$$

$$\text{mol}(\text{MgCO}_3) = \frac{4.2}{84} = 0.05 \text{ mol}$$

$$24 \text{ dm}^3 \Rightarrow 24000 \text{ cm}^3$$

$$\text{mol} = \frac{\text{vol}}{24000}$$

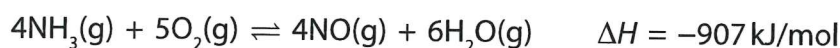
$$\text{vol} = 0.05 \times 24000 = 1200$$

$$\text{volume} = \underline{1200} \text{ cm}^3$$

(Total for Question 6 = 11 marks)

- 7 Ammonia is manufactured on a large scale and is used to make fertilisers such as ammonium nitrate (NH_4NO_3).

- (a) The first stage in the manufacture of ammonium nitrate is to react ammonia gas with oxygen gas.

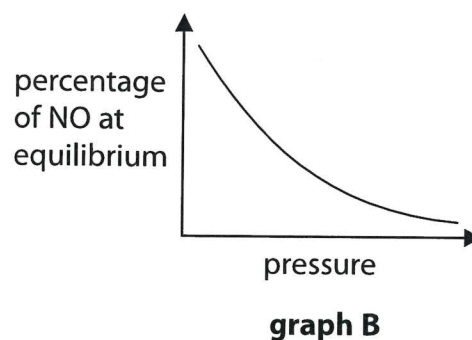
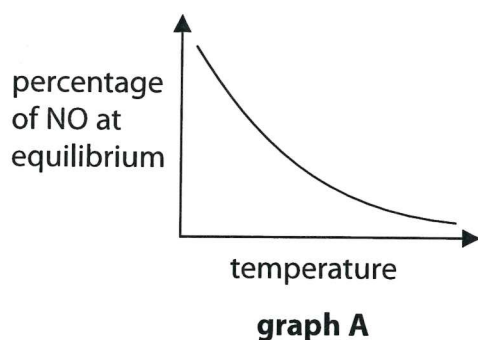


The reaction is carried out at a pressure of about 10 atm and at a temperature of 800°C , in the presence of a catalyst.

If the mixture is left for long enough in a sealed container, the reaction reaches a position of dynamic equilibrium.

Graph A shows how the percentage of nitrogen monoxide (NO) in the equilibrium mixture varies with temperature at constant pressure.

Graph B shows how the percentage of nitrogen monoxide (NO) in the equilibrium mixture varies with pressure at constant temperature.



- (i) Explain why the percentage of NO at equilibrium decreases in each case.

(4)

Graph A • Backward reaction is endothermic

- Increase in temperature shifts equilibrium to the left so NO decreases

Graph B • Fewer gas molecules on the left

- Increase in pressure shifts equilibrium to the left so NO decreases

- (ii) Explain why the use of a catalyst has no effect on the position of equilibrium in a reversible reaction.

(2)

- catalyst increases the rate of both forward and backward reactions
- in the same proportion

- (b) The second stage in the manufacture of ammonium nitrate is to convert the nitrogen monoxide into nitric acid. The nitric acid is then reacted with concentrated aqueous ammonia as shown in this equation.



- (i) State, in terms of proton transfer, why this reaction is classified as an acid-base reaction.

(1)

Proton transferred from HNO_3 to NH_3

- (ii) Calculate the volume of 14.8 mol / dm^3 aqueous ammonia that is required to exactly neutralise 150 dm^3 of a solution of nitric acid of concentration 15.8 mol / dm^3 .

(2)

$$\begin{aligned}\text{mol}(\text{HNO}_3) &= \text{vol} \times \text{conc} \\ &= 150 \times 15.8 \\ &= 2370 \text{ mol}\end{aligned}$$

$$\begin{aligned}\text{vol}(\text{NH}_3) &= \frac{\text{mol}}{\text{conc}} \\ &= \frac{2370}{14.8} = 160 \text{ dm}^3\end{aligned}$$

volume of aqueous ammonia = 160 dm³

(Total for Question 7 = 9 marks)

8 Polymers can be classified as addition polymers or condensation polymers.

(a) An addition polymer can be formed from the monomer $\text{CH}_2=\text{CHCl}$

(i) Name this monomer.

(1)

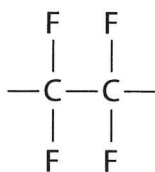
chloroethene

(ii) Name the addition polymer formed from this monomer.

(1)

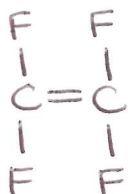
poly chloroethene

(b) The diagram shows the repeat unit of a different addition polymer.



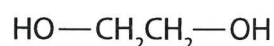
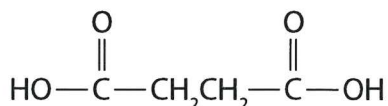
Draw the displayed formula of the monomer used to make this polymer.

(1)



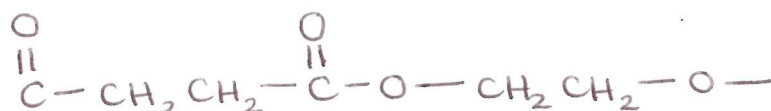
(c) Polyesters are condensation polymers.

The structures of two monomers that are used to make a polyester are:



- (i) Draw the structure of the repeat unit of the polyester formed from these two monomers.

(2)



- (ii) Identify the small molecule formed when these two monomers form the polyester.

(1)

water

(Total for Question 8 = 6 marks)

9 Grapes contain glucose that can be fermented to make ethanol.



(a) The grapes are collected and crushed to produce an aqueous solution containing glucose. Yeast is added to the solution and the mixture is left to ferment at a temperature of about 30 °C in the absence of air.

(i) State why yeast is added.

(2)

- Provides enzyme
- to increase rate of reaction

(ii) Explain why another organic compound may also be formed if fermentation is carried out in the presence of air.

(2)

- oxygen reacts with ethanol
- to form ethanoic acid

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(iii) Explain why 30°C is considered to be an optimum temperature for this reaction.

(2)

- Reaction too slow at lower temperatures
- At higher temperatures, enzyme will become denatured

(b) Ethanol can also be manufactured by reacting ethene with steam.

(i) Write the chemical equation for this reaction.

(1)



(ii) Name the type of reaction that occurs.

(1)

addition

(iii) State **two** conditions used for this reaction in industry.

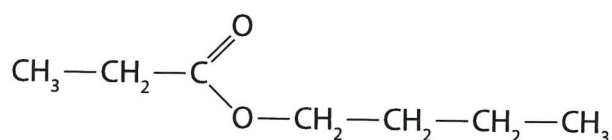
(2)

1 phosphoric acid catalyst

2 300°C

(c) Grapes also contain esters.

The formula of an ester is shown.



Deduce the name of the carboxylic acid and the alcohol that can react together to make this ester.

(2)

carboxylic acid propanoic acid

alcohol butan-1-ol

(Total for Question 9 = 12 marks)

TOTAL FOR PAPER = 70 MARKS