Oxford Cambridge and RSA

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GCSE (9–1) Chemistry A (Gateway Science)

J248/03 Paper 3, C1–C3 and C7 (Higher Tier)

Thursday 17 May 2018 – Morning

Time allowed: 1 hour 45 minutes

You must have:
- a ruler (cm/mm)
- the Data Sheet (for GCSE Chemistry A (inserted))

You may use:
- a scientific or graphical calculator
- an HB pencil

First name									
Last name									
Centre number						Candidate number			

INSTRUCTIONS
- The data sheet will be found inside this document.
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **24** pages.

SECTION A

Answer **all** the questions.

You should spend a maximum of 30 minutes on this section.

1 What is the name of the gas made when magnesium reacts with sulfuric acid?

$Mg + H_2SO_4 \rightarrow MgSO_4 + \underline{H_2} \uparrow$

A Carbon dioxide

B Carbon monoxide

C Hydrogen ✓

D Oxygen

Your answer C **[1]**

2 Which equation represents **neutralisation**?

$H^+ + OH^- \rightarrow H_2O$
acid alkali water
neutralised →

A $4H^+ \longrightarrow 2H_2$

B $H_2O \longrightarrow 2H^+ + O^{2-}$

C $H^+ + OH^- \longrightarrow H_2O$ ✓

D $O_2 + H_2 \longrightarrow H_2O + O^{2-}$

Your answer C **[1]**

3 Which statement about nanoparticulate materials is **not** correct?

A Nanoparticles are much smaller than atoms. ✗

B Nanoparticulate materials can be used as catalysts. ✓

C Nanoparticulate materials have an extremely large surface area to volume ratio. ✓

D There are possible risks when using nanoparticulate materials which are difficult to predict. ✓

Your answer A **[1]**

4 Ethanol is a liquid at room temperature. It has a low melting point and boiling point.

Why?

A Ethanol is an ionic compound. x

B The forces of attraction between ethanol molecules are strong. x

C The forces of attraction between ethanol molecules are weak. ✓

D There are no forces of attraction between ethanol molecules. x

Your answer C **[1]**

5 Look at the equation.

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

Which substance is the **oxidising agent** in this reaction?

A CH_4

B CO_2

C H_2O

D O_2

CH_4 is being oxidised to CO_2
by O_2
↑ oxidising agent.

Your answer D **[1]**

6 Which statement about **covalent** bonding is true?

A Electrons are transferred from one atom to another. x

B Electrons are delocalised. x

C Electrons are shared between atoms. ✓

D Ions are formed. x ← when e^- lost or gained

Your answer C **[1]**

7 Which statement correctly describes a pure substance?

A Consists of just one element or compound

B Has a low melting point impurities lower the m.p.

C Is a mixture of two or more substances

D Melts over a range of temperatures impurities cause this

Pure substances have sharp m.p.s

Your answer A **[1]**

8 A student separates a dye using thin layer chromatography.

She puts a thin layer of solid alumina onto a glass plate. She puts the dye on the pencil line. She puts the glass plate into a tank containing water.

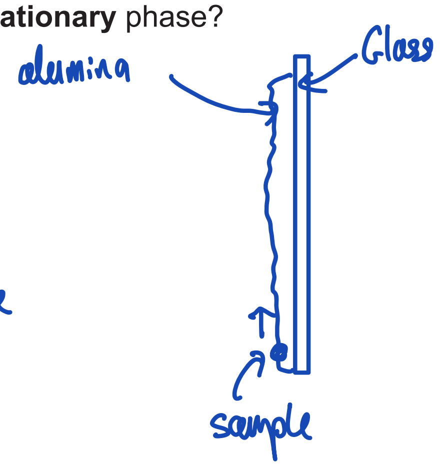
Which of the following is the **stationary** phase?

A Alumina

B Glass - 'support'

C Pencil line

D Water - mobile phase



Your answer A **[1]**

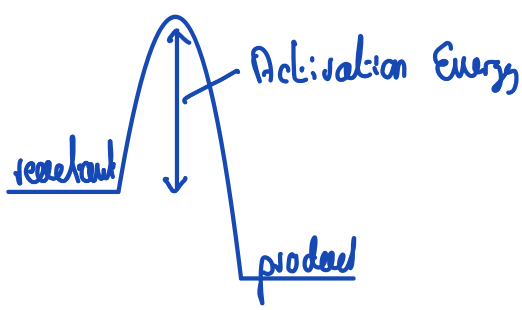
9 What is the **activation energy** for a reaction?

A The difference between the energy of the reactants and the products Enthalpy of reaction ΔH

B The energy needed for a reaction to start

C The energy of the products

D The energy of the starting materials



Your answer B **[1]**

10 Which is the **best** explanation of a **concentrated** acid?

A The acid is completely ionised in solution in water. – strong acid

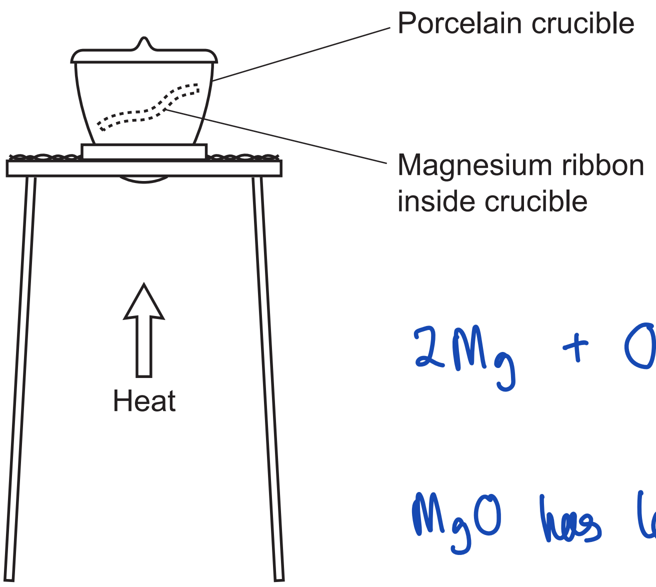
B The acid is partially ionised in solution in water. – weak acid

C There is a large amount of acid and a small amount of water. ✓

D There is a large amount of water and a small amount of acid. – dilute

Your answer C **[1]**

11 Magnesium is heated in a crucible.



$2Mg + O_2 \longrightarrow 2MgO$

MgO has larger mass than Mg

The mass of the crucible and magnesium **increases**.

Which statement is the **best** explanation for this?

A Oxygen is given off. ✗ would lose mass

B The magnesium melts. ✗ mass stays the same

C The magnesium is oxidised to magnesium oxide. ✓

D The magnesium reacts to make magnesium carbonate. ✗

Your answer C **[1]**

12 The equation shows a reaction that involves both oxidation and reduction.

$$Fe_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Fe$$

OILRIG

Which statement about **reduction** is correct?

Reduction = gain e^-

A The gain of oxygen and the gain of electrons by a substance

B The gain of oxygen and the loss of electrons by a substance

C The loss of oxygen and the gain of electrons by a substance ✓

D The loss of oxygen and the loss of electrons by a substance

Your answer C **[1]**

13 Niels Bohr was involved in the development of the atomic model.

Which of these statements describes his work?

A He developed the idea of a nuclear atom.

B He developed the plum-pudding model of the atom.

C He stated that atoms were like tiny solid balls.

D He stated that electrons exist in fixed energy levels. ✓

Your answer D **[1]**

14 What is the approximate size of a nanoparticle?

A 0.07 nm } too small

B 0.40 nm

Nanoparticle size:

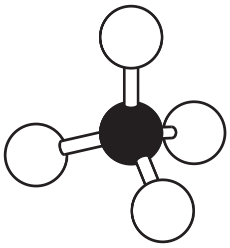
1 to 100 nm

C 50 nm ✓

D 1000 nm too big

Your answer C **[1]**

15 Look at the diagram of a methane molecule.



Which statement about methane is correct?

shared in covalent bonds

A Electrons are transferred from hydrogen atoms to carbon atoms.

B The covalent bonds in methane are weak. covalent bonds are strong

C The force of attraction between methane molecules is weak.

covalent

D The ionic bonds between carbon and hydrogen are very strong.

Your answer $\boxed{C}$ **[1]**

SECTION B

Answer **all** the questions.

16 Magnesium is an element. It is solid at room temperature.

(a) (i) **Solid** magnesium cannot be compressed.

Why?

Because Mg ions are already in a close packed structure **[1]**

(ii) **Solid** magnesium **cannot** flow, but **liquid** magnesium **can** flow.

Explain why.

Particles in a solid are in fixed positions. They can vibrate but not 'flow' or move from these positions. Particles in a liquid can flow, or move past each other as forces between particles in a liquid are less than in a solid. **[3]**

(iii) Magnesium **gas** completely fills any container it is put in.

Explain why.

The particles are moving quickly in all directions, have weak forces between each other and are spread out. **[2]**

Mg H_2O

(b) Magnesium reacts with water. Magnesium hydroxide, $Mg(OH)_2$, and hydrogen, H_2, are made.

Write a balanced symbol equation for this reaction.

$Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$ **[2]**

(c) Magnesium nitrate has the formula $Mg(NO_3)_2$.

Calculate the relative formula mass of magnesium nitrate.

RAM of Mg = 24.3

M_r of NO_3 = $14 + (3 \times 16) = 62$

M_r of $Mg(NO_3)_2$ = $24.3 + (2 \times 62)$

= $148.3\ g\ mol^{-1}$

Answer = 148.3 **[1]**

17 A student has a solution of hydrochloric acid, HCl, and a solution of sodium hydroxide, NaOH.

He wants to make a pure, dry sample of sodium chloride.

(a) Describe how he can do this.

Include the apparatus he should use and his method.

Prepare NaCl by the titration method:
Place HCl acid in burette
Pipette a known volume of NaOH into flask
Use universal indicator or pH meter
Add HCl to NaOH until colour change / pH = 7
Repeat to obtain concordant results
Repeat titration without indicator
Evaporate off the water and crystallise **[4]**

(b) Write a **balanced symbol** equation for the reaction.

$HCl + NaOH \rightarrow NaCl + H_2O$ **[1]**

(c) The student also investigates other reactions.

The table shows the salts he can make from different starting materials.

Complete the table.

Acid used	Other starting material	Salt made
Sulfuric acid	Copper oxide	Copper sulfate
Nitric acid	Zinc carbonate	Zinc nitrate
Hydrochloric acid	Magnesium hydroxide	Magnesium chloride

[3]

(d) What **type** of reaction happens when sulfuric acid reacts with copper oxide?

Neutralisation reaction.

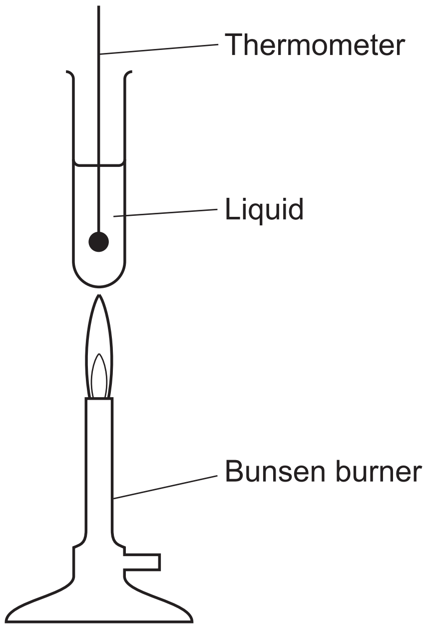
[1]

$H_2SO_4 + CuO \rightarrow CuSO_4 + H_2O$

$2H^+ + O^{2-} \rightarrow H_2O$

Neutralisation

18 A student is measuring the boiling point of some liquids.



She measures the boiling point of water, petrol and ethanol.

(a) The student's method is not safe.

Explain why it is not safe and explain how she could improve her method to make it safer.

Petrol and ethanol are flammable.
Need to use a water bath or heating mantle.
.... **[2]**

(b) The student looks up some data on melting points and boiling points.

solid → liq.   liq → gas

Substance	Formula	Melting point (°C)	Boiling point (°C)	State at 25 °C
Propane	C_3H_8	–188	–42 25	Gas
Hexane	C_6H_{14}	–95 25	69	Liquid
Icosane	$C_{20}H_{42}$	25 37	343	Solid

Complete the table to show the states of propane and hexane at 25 °C. **[2]**

(c) Propane (C_3H_8) burns in oxygen, O_2. Carbon dioxide (CO_2) and water (H_2O) are made.

Write a **balanced symbol** equation for this reaction.

$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$ **[2]**

$C_3H_8 + O_2 \longrightarrow 3CO_2 + H_2O$ Balance C_3

$C_3H_8 + O_2 \longrightarrow 3CO_2 + 4H_2O$ Balance H_8

$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$ Balance O needed

19 Look at the information about two atoms of chlorine.

$^{35}_{17}Cl$ $^{37}_{17}Cl$

The **atomic number** of chlorine is 17.

(a) What is meant by atomic number?

Number of protons in the nucleus. **[1]**

(b) These two atoms of chlorine are **isotopes**.

Explain why these two atoms of chlorine are isotopes.

Isotopes have the same number of protons
but different numbers of neutrons. **[1]**

(c) Look at the information about other atoms and ions.

Atom or ion	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons	Electronic structure
S	16	32	16	16	16	2.8.6
B	5	11	5	11 − 5 6	5	2.3
$e^- \uparrow$ F^-	9	19	9	19 − 9 10	10	2.8
$e^- \downarrow$ Li^+	3	7	3	4	2	2

Complete the table. **[4]**

= Atomic Number

= Mass Number − Atomic Number

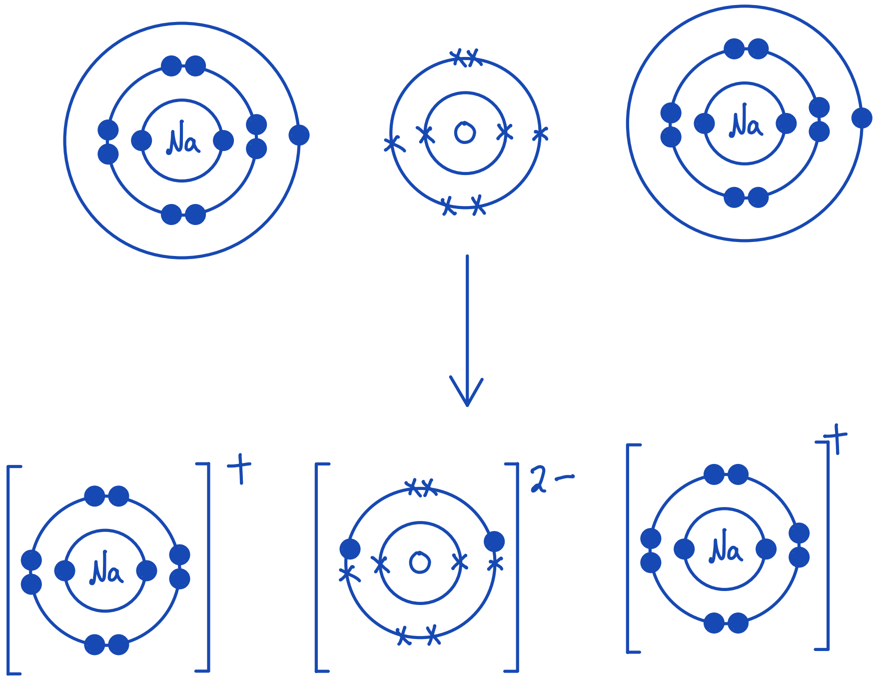
= Atomic Number (for neutral atom)

(d) (i) The electronic structure of sodium is 2.8.1. The electronic structure of oxygen is 2.6. Sodium and oxygen react together to make sodium oxide.

Sodium oxide is an **ionic** compound.

Draw 'dot and cross' diagrams to show the ions made when sodium reacts with oxygen.

Show the charges on the ions.



[3]

(ii) What is the **formula** of sodium oxide?

Na_2O **[1]**

20 A student has a mixture of three substances.

Look at some information about these substances.

Substance	Melting point (°C)	Boiling point (°C)	Solubility in water
Sand	1710	2230	Insoluble
Sodium chloride	801	1413	Soluble
Water	0	100	

(a) Describe how the student can separate the mixture to get pure samples of all **three** substances.

Explain why each method of separation works.

1) Filter the mixture to remove the sand, as sand is insoluble in water. (NaCl is soluble)

2) Distil the filtered mixture. NaCl will remain in the flask and pure water condenses.

[4]

(b) The student separates two solid substances **A** and **B**.

She wants to check that they are **pure**.

She measures the melting points of four samples of solid **B**.

Look at her results.

Sample	Melting point (°C)
1	109
2	105
3	104–108
4	110–112

The student knows that a pure sample of solid **B** has a melting point of 110 °C.

She concludes that sample 4 is the purest sample of solid **B**.

Do the results support her conclusion?

Explain your answer using evidence from the table.

No, because Sample 4 has a range higher than 110°C and a pure sample of B cannot have a m.p. > 110 °C. Pure samples do not melt over a range, they have specific m.p. Impurities lower the m.p. **[3]**

Sample 1 is likely to be most pure.

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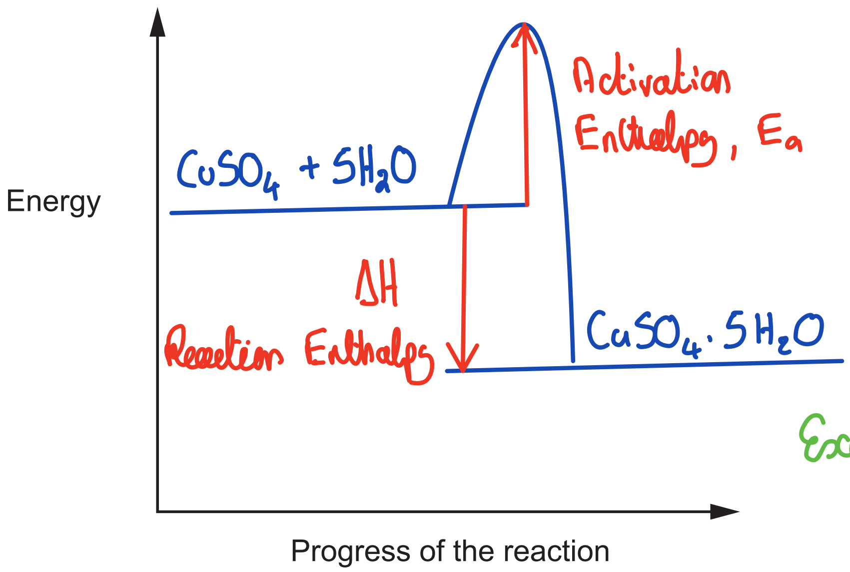
21 Anhydrous copper sulfate reacts with water to make hydrated copper sulfate.

$CuSO_4 + 5H_2O \longrightarrow CuSO_4.5H_2O$

Anhydrous copper sulfate + Water ⟶ Hydrated copper sulfate

The reaction is **exothermic.**

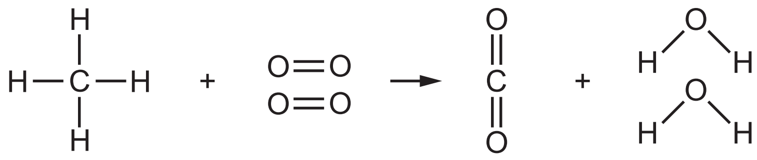
(a) Draw and label a reaction profile for this reaction.



Exothermic, ΔH -'ve

[3]

(b) Two students investigate the burning of methane in oxygen.



Methane — Oxygen — Carbon dioxide — Water

4 C–H   2 O=O   2 C=O   4 O–H

Look at the table of bond energies.

Bond	Bond energy (kJ/mol)
O–H	459
C=O	799
O=O	494
C–H	x

The reaction is exothermic and 802 kJ of energy are given out when 1 mole of methane burns.

The students have looked up the bond energies. They have different values for the C–H bond energy.

Student A thinks the C–H bond energy is 432 kJ/mol. Student B thinks the C–H bond energy is 411 kJ/mol.

Who is correct?

Use the bond energies and the energy given out in the reaction to calculate the C–H bond energy.

Energy required to break bonds: 4 C–H $4x$
2 O=O $2 \times 494 = 988$

$4x + 988$

Energy released on forming bonds: 2 C=O $2 \times 799 = 1598$
4 O–H $4 \times 459 = 1836$

3434

$\Delta H = E_{\text{bond breaking}} - E_{\text{bond forming}} = -802$

$4x + 988 - 3434 = -802$

$4x = -802 - 988 + 3434$

$4x = 1644$

$x = \frac{1644}{4} = 411$

Answer = ...411........ kJ/mol **[3]**

4

22 Copper oxide can be reduced to copper by reaction with hydrogen.

$$CuO + H_2 \longrightarrow Cu + H_2O$$

A reaction mixture contains 1.59 g of copper oxide and 0.20 g of hydrogen.

1.27 g of copper and 0.36 g of water are made.

Calculate the number of moles of each substance to determine the **limiting reactant** in this reaction.

Explain your choice.

The relative atomic mass of Cu is 63.5, of O is 16 and of H is 1.

M_r CuO $= 63.5 + 16 = 79.5$ g mol^{-1}

M_r H_2 $= 2 \times 1 = 2$

M_r H_2O $= (2 \times 1) + 16 = 18$

Number of moles of CuO = $\frac{1.59}{79.5} = 0.02$

Number of moles of H_2 = $\frac{0.2}{2} = 0.1$

Number of moles of Cu = $\frac{1.27}{63.5} = 0.02$

Number of moles of H_2O = $\frac{0.36}{18} = 0.02$

The limiting reactant is CuO because it is the starting material that is present in the smaller quantity. **[4]**

$$CuO + H_2 \longrightarrow Cu + H_2O$$

$\underline{0.02}$ 0.1 0.02 0.02

$0.02 < 0.1$

23 Look at the diagram.

It shows part of Mendeleev's Periodic Table which was developed in 1871.

Mendeleev arranged the elements in order of relative atomic mass.

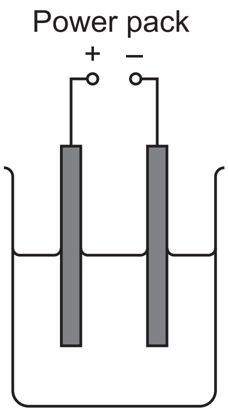
Group	1	2	3	4	5	6	7	
Periods								
1	H 1.008							
2	Li 6.939	Be 9.012	B 10.81	C 12.011	N 14.007	O 15.999	F 18.998	
3	Na 22.99	Mg 24.31	Al 29.98	Si 28.09	P 30.974	S 32.06	Cl 35.453	
4	K 39.102	Ca 40.08			As 74.92	Se 78.96	Br 79.909	
5	Rb 85.47	Sr 87.62	In 114.82	Sn 118.69	Sb 121.75	Te 127.60	I 126.90	
6	Cs 132.90	Ba 137.84	Tl 204.37	Pb 207.19	Bi 208.98			

Describe the differences between Mendeleev's Periodic Table and the modern-day version found in the insert.

Mendeleev's periodic table is ordered by atomic mass, whereas modern day table is ordered by atomic number. Mendeleev's periodic table has gaps - left for elements to be discovered. Modern table is complete. Mendeleev's periodic table has no noble gases or transition elements.

[3]

24 A student is investigating the electrolysis of copper sulfate solution.



+

Pt

OH^-

SO_4^{2-}

Not a halide

$\therefore O_2$ given off.

–

H^+

Cu^{2+}

Cu less reactive than H, $\therefore$ Cu discharged.

Cu

Cu anode dissolves

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

He does two experiments.

Experiment **1** uses platinum electrodes. Experiment **2** uses copper electrodes.

(a) Complete the table to show the products at each electrode.

Experiment	What happens at cathode (–)	What happens at anode (+)
1	Copper deposited	Oxygen made
2	Copper deposited	Copper anode dissolves

[2]

(b) Copper electrodes are **non-inert** electrodes.

What is meant by non-inert electrodes?

Non-inert electrodes are changed during electrolysis **[1]**

(c) Look at the results for experiment 2 using **copper** electrodes.

At the cathode copper ions, Cu^{2+} gain electrons to make copper atoms.

Write the **half equation** for this reaction.

Use e^- to represent an electron.

$Cu^{2+} + 2e^- \rightarrow Cu$ **[2]**

(d) The student also electrolyses sodium chloride solution using platinum (inert) electrodes.

At the cathode, hydrogen gas is made rather than sodium metal.

Explain why.

Hydrogen is less reactive than sodium

So it is discharged before sodium. **[2]**

25* Look at the data about some substances.

Substance	Melting point (°C)	Boiling point (°C)	Does it conduct electricity?	Density (g/cm^3)
A	0	100	no	1.0
B	>3000	>4000	no	3.5
C	801	1413	Solid does not conduct but conducts when melted or when dissolved in water	2.2

Explain the type of **bonding** present in each substance **A**, **B** and **C**.

Relate the type of bonding to the **properties** of each substance.

A has low m.p. and b.p. because there are weak intermolecular forces. A does not conduct electricity because there are no free electrons or ions.
A is simple molecular, covalently bonded.
A is likely to be water or other covalent structure.

B has high m.p and b.p. because there are many strong covalent bonds. It does not conduct electricity because there are no free electrons or ions.
B is a covalently bonded giant covalent structure, likely to be diamond, or other giant covalent structure,

[6]

C has high m.p. and b.p. because there are strong electrostatic forces of attraction between oppositely charged ions. C does not conduct as a solid because the ions cannot move but does when molten or dissolved in water as the ions can move. C is an ionic compound, likely to be sodium chloride or another ionic compound.

26 The value of the Avogadro constant is 6.02×10^{23}.

(a) What is meant by the Avogadro constant?

The number of entities in 1 mole

.... **[1]**

(b) Calculate the number of water molecules in 72 g of water, H_2O.

Give your answer to **3** significant figures.

M_r H_2O $= (2\times1)+16 = 18$ g mol^{-1}

N° moles of H_2O in 72g $= \frac{72\text{g}}{18 \text{ g mol}^{-1}} = 4$ moles

N° molecules of H_2O in 4 moles $= 4 \times 6.02\times10^{23} = 2.408 \times 10^{24}$

Answer = 2.41×10^{24} **[3]**

(c) A student is reacting magnesium oxide with nitric acid.

Look at the equation for the reaction.

$$MgO + 2HNO_3 \longrightarrow Mg(NO_3)_2 + H_2O$$

The student wants to make 14.8 g of magnesium nitrate, $Mg(NO_3)_2$.

Calculate the masses of magnesium oxide and nitric acid that he needs.

N° moles of $Mg(NO_3)_2$ $= \frac{14.8}{148.3} = 0.1$ moles

Need 0.1 moles of MgO $= 0.1 \times 40.3 = 4.03$ g

Need 0.1×2 mol HNO_3 $= 0.1\times2\times63 = 12.6$ g

Mass of magnesium oxide needed = 4.0 g

Mass of nitric acid needed = 12.6 g **[4]**

END OF QUESTION PAPER

RAM of Mg = 24.3

M_r of NO_3 = $14 + (3\times16) = 62$

M_r of $Mg(NO_3)_2$ = $24.3 + (2\times62)$

= 148.3 g mol^{-1}

M_r of HNO_3 = $1 + 14 + (3\times16) = 63$ g mol^{-1}

M_r of MgO = $24.3 + 16 = 40.3$ g mol^{-1}

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).