Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary

Unit 2: Application of Core Principles of Chemistry

Thursday 8 January 2015 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
WCH02/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P45042A

6/6/6/6/4/3/3/

P 4 5 0 4 2 A 0 1 2 4

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following are properties of the liquid, 1-bromobutane?

	Solubility in water	Effect of a charged rod on a stream of the liquid
☒ **A**	soluble	stream diverted
☒ **B**	soluble	stream unaffected
☒ **C**	insoluble	stream diverted
☒ **D**	insoluble	stream unaffected

(Total for Question 1 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

2 (a) The strongest intermolecular forces in liquid ammonia are

(1)

☒ **A** covalent bonds.

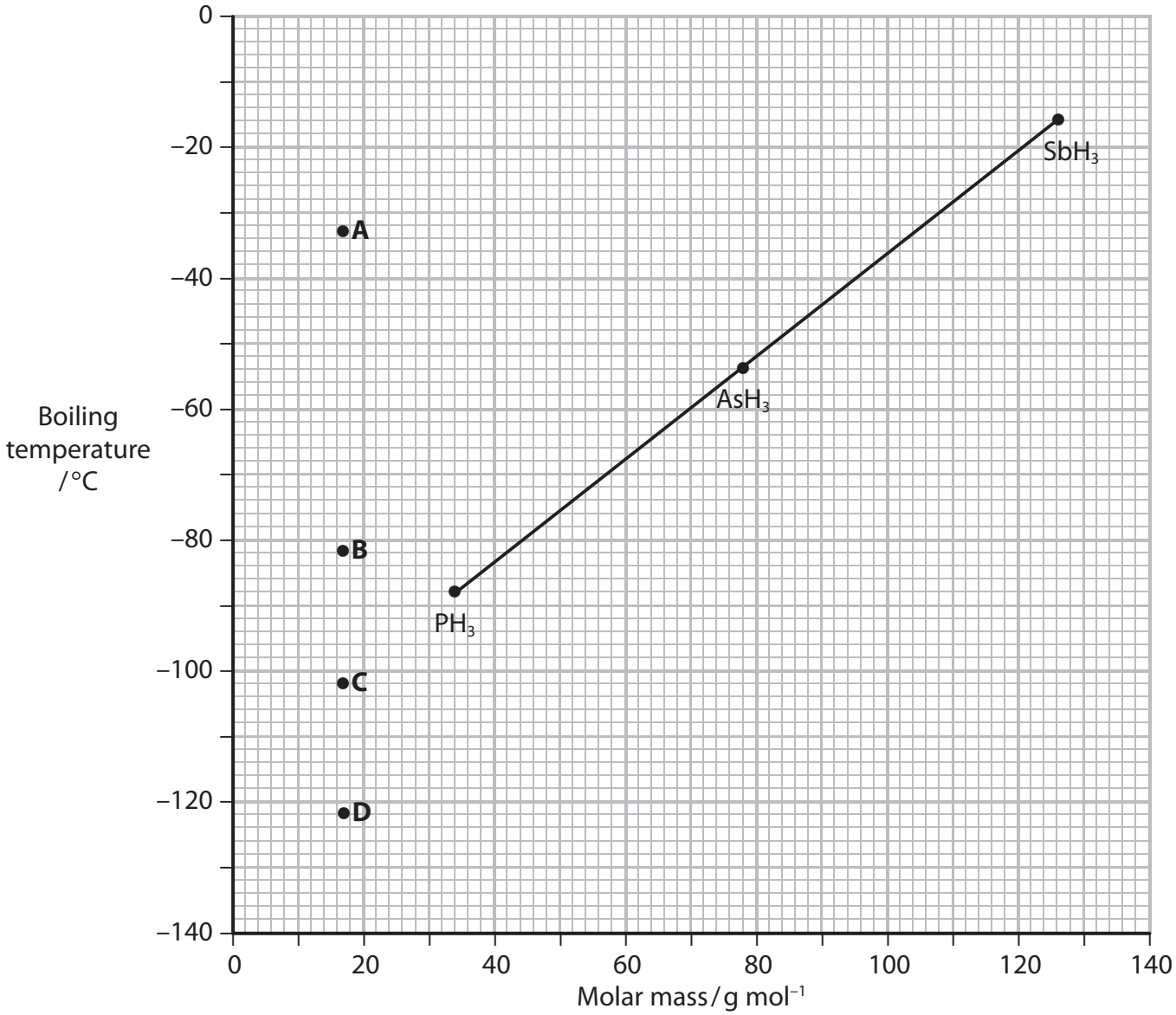
☒ **B** hydrogen bonds.

☒ **C** London forces.

☒ **D** permanent dipole-dipole forces.

(b) The graph below shows the boiling temperatures for the Group 5 hydrides. Select the most likely boiling temperature for ammonia.

(1)



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 2 = 2 marks)

3 The equation for the reaction of chlorine with water is shown below.

$$Cl_2 + H_2O \rightleftharpoons HCl + HClO$$

This reaction is an example of

☒ **A** decomposition.

☒ **B** displacement.

☒ **C** disproportionation.

☒ **D** neutralization.

(Total for Question 3 = 1 mark)

4 The oxidation number of chlorine in $HClO_3$ is

☒ **A** –1

☒ **B** +3

☒ **C** +5

☒ **D** +7

(Total for Question 4 = 1 mark)

5 The following equilibrium was established with all three substances present.

$$ICl(l) + Cl_2(g) \rightleftharpoons ICl_3(s)$$

brown pale green yellow

What would be the effect of increasing the pressure on this equilibrium system?

☒ **A** No change.

☒ **B** An increase in the amount of the brown liquid.

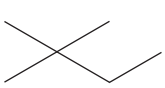
☒ **C** An increase in the amounts of the brown liquid and the pale green gas.

☒ **D** An increase in the amount of the yellow solid.

(Total for Question 5 = 1 mark)

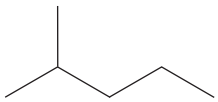
Use this space for any rough working. Anything you write in this space will gain no credit.

6 Which of the following isomers of C_6H_{14} has the **lowest** boiling temperature?

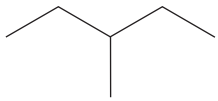


A

B



C



D

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 6 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

7 Which of the following compounds has the **highest** boiling temperature?

M_r = relative molecular mass

- ☒ **A** cyclopentane $M_r = 70$
- ☒ **B** pentane $M_r = 72$
- ☒ **C** butan-1-ol $M_r = 74$
- ☒ **D** ethane-1,2-diol $M_r = 62$

(Total for Question 7 = 1 mark)

8 The following industrial processes produce ethanol.

Hydration of ethene: $C_2H_4(g) + H_2O(g) \xrightarrow{H_3PO_4} C_2H_5OH(l)$

Fermentation of glucose: $C_6H_{12}O_6(aq) \xrightarrow{\text{yeast}} 2C_2H_5OH(aq) + 2CO_2(g)$

(a) What is the atom economy by mass of the fermentation process?
Use the Periodic Table as a source of data.

(1)

- ☒ **A** 25.6%
- ☒ **B** 46.0%
- ☒ **C** 51.1%
- ☒ **D** 92.0%

(b) From a 'green chemistry' perspective, which of the following is an advantage of the hydration of ethene compared to the fermentation process?

(1)

- ☒ **A** The catalyst is less corrosive.
- ☒ **B** A higher temperature is needed.
- ☒ **C** Ethene is a renewable resource.
- ☒ **D** The ethanol is easier to purify.

(Total for Question 8 = 2 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

9 Which of the following does **not** damage the ozone layer?

☒ **A** CCl_3CF_3

☒ **B** CF_4

☒ **C** NO

☒ **D** CH_2ClF

(Total for Question 9 = 1 mark)

10 Microwave energy can only be used for heating reactions involving polar reactants.

Which of the following reactions **cannot** be heated with microwave energy?

☒ **A** $C_5H_{12} + Cl_2 \rightarrow C_5H_{11}Cl + HCl$

☒ **B** $C_2H_5OH + HBr \rightarrow C_2H_5Br + H_2O$

☒ **C** $C_2H_5I + KOH \rightarrow C_2H_5OH + KI$

☒ **D** $CH_3CHO + ½O_2 \rightarrow CH_3COOH$

(Total for Question 10 = 1 mark)

11 In the mechanism for the addition of bromine to an alkene, a bromide ion attacks a carbocation. The attacking bromide ion is acting as

☒ **A** a catalyst.

☒ **B** an electrophile.

☒ **C** a free radical.

☒ **D** a nucleophile.

(Total for Question 11 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

12 The relative greenhouse factor of a gas compares the greenhouse effect of a molecule of the gas to that of a molecule of carbon dioxide.

Gas	Percentage by volume in the atmosphere	Relative greenhouse factor per molecule
CO_2	3.5×10^{-2}	1
CH_4	1.7×10^{-4}	30
N_2O	3.1×10^{-5}	200
CCl_2F_2	4.8×10^{-6}	25 000

Using **only** the data in the table above, select the gas that has the greatest greenhouse effect in the atmosphere.

☒ **A** CO_2

☒ **B** CH_4

☒ **C** N_2O

☒ **D** CCl_2F_2

(Total for Question 12 = 1 mark)

13 In the Contact Process for the production of sulfuric acid, there is a step in which sulfur dioxide is oxidized to sulfur trioxide as shown below.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H = -198 \text{ kJ mol}^{-1}$$

A high yield is obtained with the following conditions:

- 2 atm and 700 K
- 1:1 mole ratio of sulfur dioxide and oxygen
- catalyst vanadium(V) oxide, V_2O_5

In comparison with the conditions given above, which of the following would shift the equilibrium position to the right?

☒ **A** Lowering the pressure.

☒ **B** Increasing the temperature.

☒ **C** Increasing the excess of oxygen.

☒ **D** Using a more finely divided catalyst.

(Total for Question 13 = 1 mark)

14 Diamond, buckminsterfullerene and graphite are all forms of carbon.
A significant difference between buckminsterfullerene and the other two forms is that only buckminsterfullerene

- ☒ **A** has good electrical conductivity.
- ☒ **B** has a precise molecular formula.
- ☒ **C** is tough and rigid.
- ☒ **D** has some carbon atoms with only three covalent bonds.

(Total for Question 14 = 1 mark)

15 An iodine-thiosulfate titration is carried out with the thiosulfate solution in the burette and the iodine solution in the conical flask.

If an indicator is **not** used, then the colour change at the end-point is

- ☒ **A** pale yellow to colourless.
- ☒ **B** pale yellow to clear.
- ☒ **C** blue-black to colourless.
- ☒ **D** brown to clear.

(Total for Question 15 = 1 mark)

16 Which of the following is **not** true of the hydrogen halides, HCl, HBr and HI?
These hydrogen halides

- ☒ **A** form white smoke when in contact with ammonia vapour.
- ☒ **B** dissolve in water to form strong acids.
- ☒ **C** are usually prepared by the action of sulfuric acid on the sodium halide.
- ☒ **D** produce steamy fumes in moist air.

(Total for Question 16 = 1 mark)

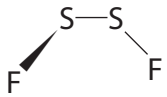
17 What is observed when a mixture of bromoethane and aqueous silver nitrate is warmed?

- ☒ **A** Brown solution
- ☒ **B** Cream precipitate
- ☒ **C** Decolorisation
- ☒ **D** Silver precipitate

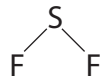
(Total for Question 17 = 1 mark)

18 Sulfur can combine with fluorine to form a number of different compounds, some of which are shown below. From the diagrams given, which compound will **not** be polar?

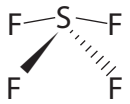
☒ **A** Disulfur difluoride, S_2F_2



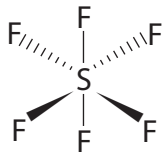
☒ **B** Sulfur difluoride, SF_2



☒ **C** Sulfur tetrafluoride, SF_4



☒ **D** Sulfur hexafluoride, SF_6



(Total for Question 18 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

19 This is a question about catalysis.

A spectacular demonstration of catalytic oxidation is the addition of chromium(III) oxide to ammonia gas in the presence of oxygen. This produces flashes, sometimes described as 'fireflies'.

Some concentrated ammonia solution is allowed to vaporise in a very large flask. Heated chromium(III) oxide catalyst is added.

The equation below shows one possible reaction.

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$

(a) The nitrogen atoms in ammonia are oxidized. Give the oxidation numbers of the nitrogen atoms in ammonia and nitrogen monoxide.

(2)

NH_3 ..... NO .....

(b) Nitrogen monoxide is an example of a free radical.

(i) Explain why nitrogen monoxide is classed as a free radical.

(1)

.....

.....

(ii) Draw the dot and cross diagram of nitrogen monoxide, using dots (●) for the nitrogen electrons and crosses (×) for the oxygen electrons. Show outer shell electrons only.

(2)

(c) Suggest **one** suitable safety precaution for this demonstration. Justify your choice. You can assume that the demonstrator is wearing a lab coat and safety goggles.

(2)

.....

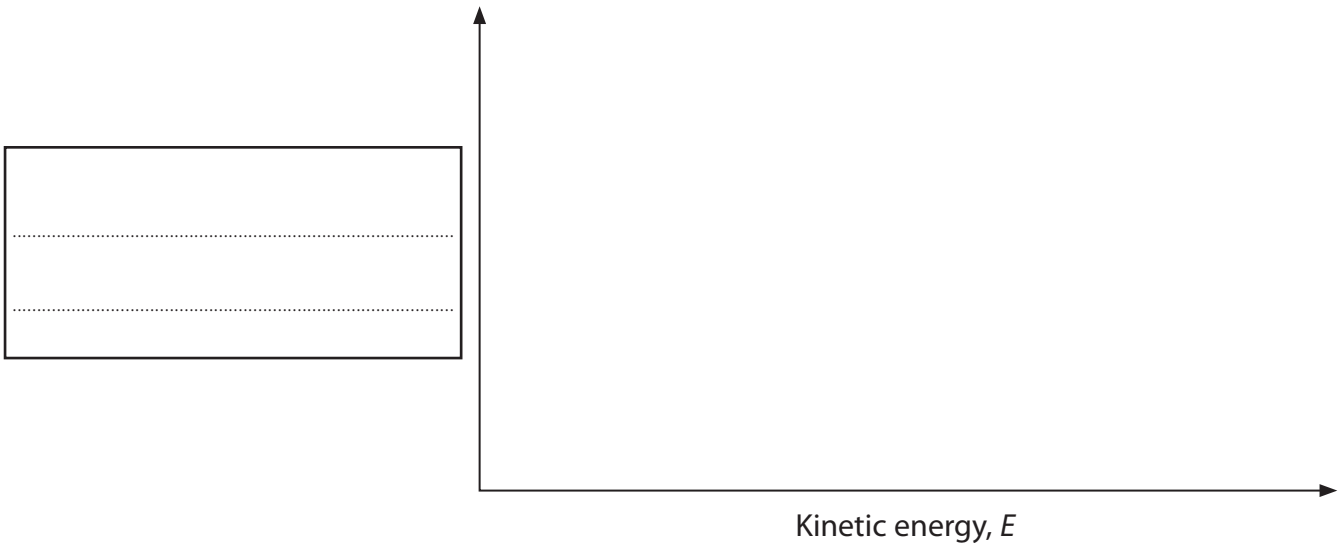
.....

.....

.....

(d) (i) Draw a Maxwell-Boltzmann diagram on the axes below, labelling the activation energy of the reaction and the vertical axis.

(2)



*(ii) Use your diagram to explain how the presence of a catalyst such as chromium(III) oxide affects the rate of a chemical reaction.

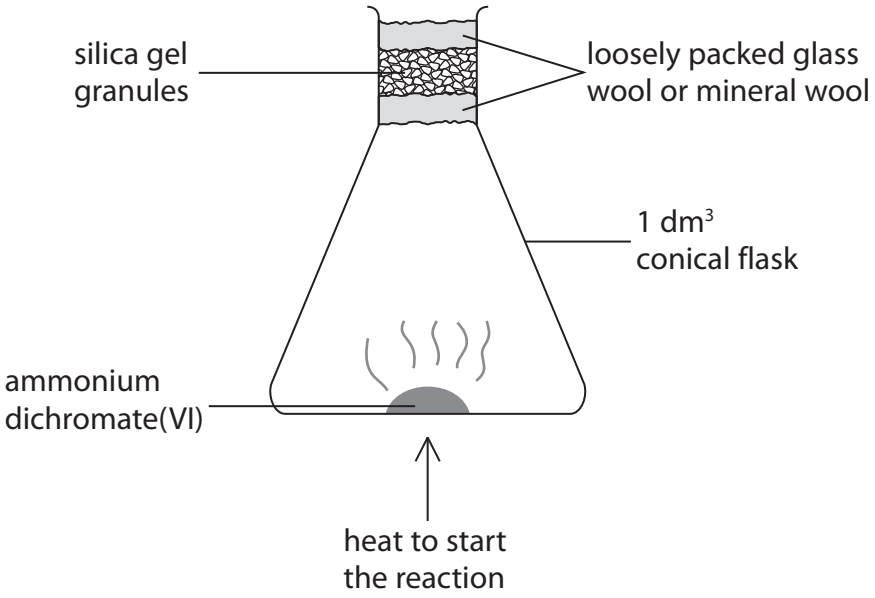
(2)

(e) Suggest how solid catalysts work in gaseous reactions.

(2)

(f) The chromium(III) oxide catalyst can be produced from a remarkable demonstration commonly called the 'dichromate volcano'.

One experimental apparatus that could be used is shown below.



(i) The substance used is ammonium dichromate(VI). Give the formula of ammonium dichromate(VI).

(1)

(ii) This thermal decomposition reaction is also a redox reaction involving the oxidation of nitrogen atoms. However, it does not require oxygen gas.

Suggest how the procedure could be modified to confirm that oxygen gas is not necessary for this oxidation.

(1)

.....

.....

.....

.....

(iii) From your knowledge of other dichromate(VI) compounds, suggest the colour change that is observed in this demonstration.

(1)

.....

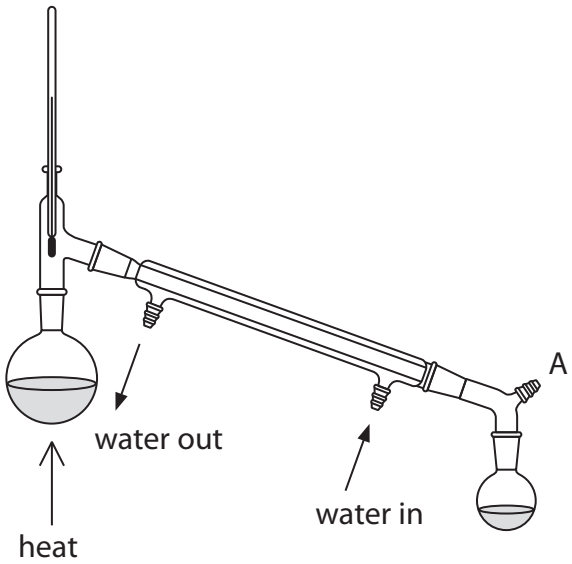
(Total for Question 19 = 16 marks)

20 Alcohols, such as ethanol, undergo a number of reactions.

(a) Write the balanced equation for the oxidation of ethanol to ethanoic acid. Use displayed formulae to show **all** the bonds in the reactants and products. Use the symbol, [O], to represent an oxygen atom from the oxidizing agent. State symbols are not required.

(3)

(b) Ethanol can be oxidized to the aldehyde, ethanal, using the apparatus shown below.



(i) State the class of alcohols that can be oxidized to aldehydes.

(1)

.....

(ii) Explain fully why ethanal, rather than ethanoic acid, is produced and collected when the apparatus in (b) is used.

(3)

(iii) State the purpose of the part of the apparatus labelled **A**.

(1)

(c) (i) The distillation product, ethanal, is dried.

What test could you use to show that the dry sample is contaminated by ethanol or ethanoic acid?
Suggest **one** reagent that could be used to test for both ethanol and ethanoic acid in the presence of ethanal. Give the observation that would be seen if either were present.

(2)

Reagent .....

Observation .....

(ii) Physical methods can also be used to identify molecules.

Give the formula of a **fragment** that produces a peak in the mass spectrum of ethanal but **not** in the mass spectrum of ethanol.

Identify **one** feature in the infrared spectrum of ethanal that distinguishes it from ethanol. Wavenumber values are not required.

(2)

Mass spectrum fragment .....

Infrared spectrum feature .....

(d) Ethanol is a highly flammable liquid. However, some other larger and more complex alcohols can be more difficult to burn. One such example is propane-1,2,3-triol, commonly called glycerol, which has the formula $CH_2OHCHOHCH_2OH$ or $C_3H_8O_3$.

(i) Write the equation for the complete combustion of propane-1,2,3-triol, using its molecular formula. State symbols are not required.

(1)

$C_3H_8O_3$ + →

(ii) Write a possible equation for the combustion of propane-1,2,3-triol in a limited supply of oxygen.
Suggest a likely observation of this reaction under these conditions. State symbols are not required.

(3)

$C_3H_8O_3$ + →

Observation .....

.....

(e) Halogenoalkanes react with aqueous hydroxide ions to form the corresponding alcohol.

(i) Name the type of reaction and mechanism.

(2)

.....

(ii) Choose a halogenoalkane that will react in this way to form ethanol.
Draw the mechanism for this reaction, using appropriate curly arrows.

Show clearly any dipoles present and the lone pair of electrons involved in the mechanism.

(3)

(Total for Question 20 = 21 marks)

TOTAL FOR SECTION B = 37 MARKS

SECTION C

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

21 Magnesium is the eighth most abundant element in the Earth's crust and is found in a number of mineral deposits such as:

Kieserite, $MgSO_4.H_2O$ Dolomite, $CaMg(CO_3)_2$ Magnesite, $MgCO_3$

These minerals have a number of uses. For example, Magnesite is used as a catalyst in the production of synthetic rubber and also to make magnesium oxide which is an important refractory lining for furnaces and kilns.

In addition, magnesium ions are found in significant quantities in sea water, from which magnesium chloride, $MgCl_2$, can be obtained. Magnesium chloride is used as a raw material for the production of the compound magnesium hydroxide.

Epsom salts contain magnesium sulfate and have a range of medicinal and other uses, including soothing aches and pains in a relaxing bath, as a topical gel for sore joints, as a laxative and as a first-aid remedy for barium chloride poisoning.

In green plants, magnesium ions, Mg^{2+}, are at the centre of the chlorophyll molecule and are vital to the process of photosynthesis. Hence magnesium compounds are commonly included in fertilizers to ensure healthy crops.

The pure form of magnesium metal also has various uses, including being a sacrificial anode for underground piping, and in flares and fireworks.

(a) Draw a labelled diagram of the experimental apparatus that you could use to form magnesium oxide from the mineral Magnesite.

Include in the diagram how you would test for any other product of the reaction. State the expected observation from the test.

(3)

Observation .....

.....

(b) Magnesium oxide can also be produced by heating magnesium hydroxide. Write an equation for this reaction. Include state symbols.

(2)

(c) Suggest the **formula** of a Group 2 hydroxide which is more soluble than magnesium hydroxide.

(1)

*(d) Magnesium oxide can also be easily produced by heating magnesium in air. However, magnesium oxide is not the only product as magnesium also reacts with nitrogen in the air.

Suggest the formula of the compound formed when magnesium reacts with nitrogen gas.

Explain how this product forms even though nitrogen gas is a very stable molecule.

Give **one** practical suggestion for how this alternative product could be avoided.

(3)

*(e) The flame test on a magnesium salt, such as magnesium chloride, produces no colour. Describe the electronic transitions involved in a flame test and suggest why there is no flame colour for magnesium chloride.

(4)

(f) Magnesium nitrate is another salt of magnesium. It decomposes when heated to produce nitrogen dioxide and oxygen.

Balance the following equation. State symbols are not required.

(1)

.....$Mg(NO_3)_2$ → .....MgO + ...NO_2 + ...O_2

(g) Give the **formula** of a reagent that could be used to produce magnesium sulfate from magnesium oxide.

(1)

.....

(h) Hydrated magnesium sulfates have the formula $MgSO_4.xH_2O$, where x varies for different minerals. In Epsom salts, the value of x is 7.
The value of x can be determined by heating a known mass of Epsom salts to remove the water of crystallization.

(i) A student carried out this determination and obtained the following results.

5.00 g of the Epsom salts was heated and the mass decreased to 2.55 g.

Calculate the number of moles of water of crystallization, x, obtained by the student. Use the Periodic Table as a source of data.
You **must** show your working. Give your answer to **three** significant figures.

(3)

Value of x = ...

*(ii) Suggest a way of improving the accuracy of the result, other than by repeating the experiment or using more precise measurements. Justify your answer.

(2)

.....

.....

.....

.....

(i) In chlorophyll, a magnesium ion is bonded to four nitrogen atoms which are in the same plane as the magnesium.

Suggest a value for the NMgN bond angle and explain how you have arrived at your suggestion.

(2)

NMgN bond angle .....

.....

.....

.....

(j) Magnesium metal is very reactive, but, unlike Group 1 elements, it is not stored under oil. Suggest a reason for this.

(1)

.....

.....

(Total for Question 21 = 23 marks)

TOTAL FOR SECTION C = 23 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103