Name: _____ ( ) Class: _____

YEAR FOUR INTEGRATED PROGRAMME
END-OF-YEAR ASSESSMENT

CHEMISTRY
Paper 2

2 October 2020
1 h 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, register number, and class on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not use highlighters, glue, correction fluid or correction tape.

Answer **all** questions.
Write all answers on the blanks provided in the question paper.
The use of a scientific calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

A copy of the Periodic Table is provided on page 2.

The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper is 80.

For Examiner's Use	
Section A (50)	
Section B (30)	
Total (80)	

This document consists of **20** printed pages

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[Turn over

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		**Key** proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Section A

Answer all the questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Choose from the following substances to answer the questions below.

aluminium sulfate	ammonium chloride	argon
calcium carbonate	iodine	lead(II) hydroxide
manganese(IV) oxide	nickel	nitrogen dioxide

Each substance can be used once, more than once or not at all.

List the substance that is

(a) in the solid state at room temperature and can be used to lower the activation energy of a reaction,

…… [1]

(b) used to fertilise soil,

…… [1]

(c) added to the blast furnace to remove impurities in the extraction of iron,

…… [1]

(d) amphoteric,

…… [1]

(e) prepared by adding excess metal carbonate to dilute acid, followed by crystallization,

…… [1]

(f) separated from a mixture by sublimation.

…… [1]

[Total: 6 Marks]

A2 Kelly attempted to separate a homogeneous liquid mixture containing three substances that are soluble in each other. The table below shows the melting and boiling points of the three substances.

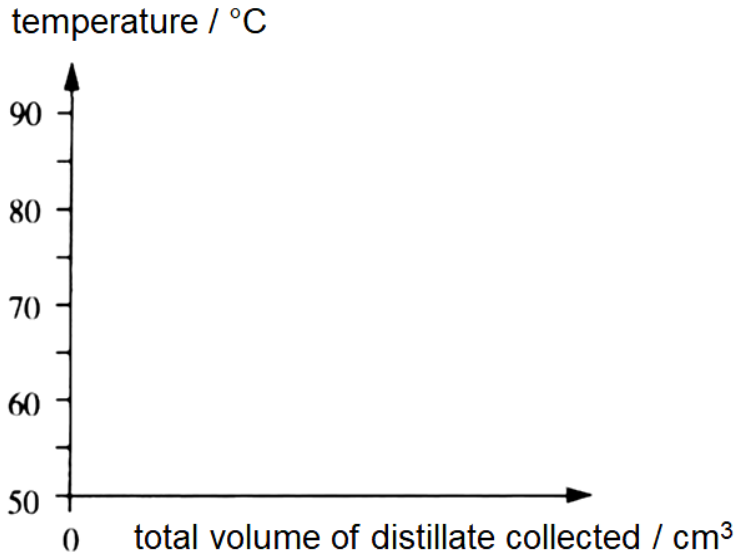
substance	melting point / °C	boiling point / °C
W	-114	55
X	-95	80
Y	50	340

Kelly carried out fractional distillation and recorded the total volume of distillate collected at various temperatures. She stopped the experiment once the thermometer reached a reading of 85 °C.

(a) State the substance(s) remaining in the mixture at the end of this experiment.

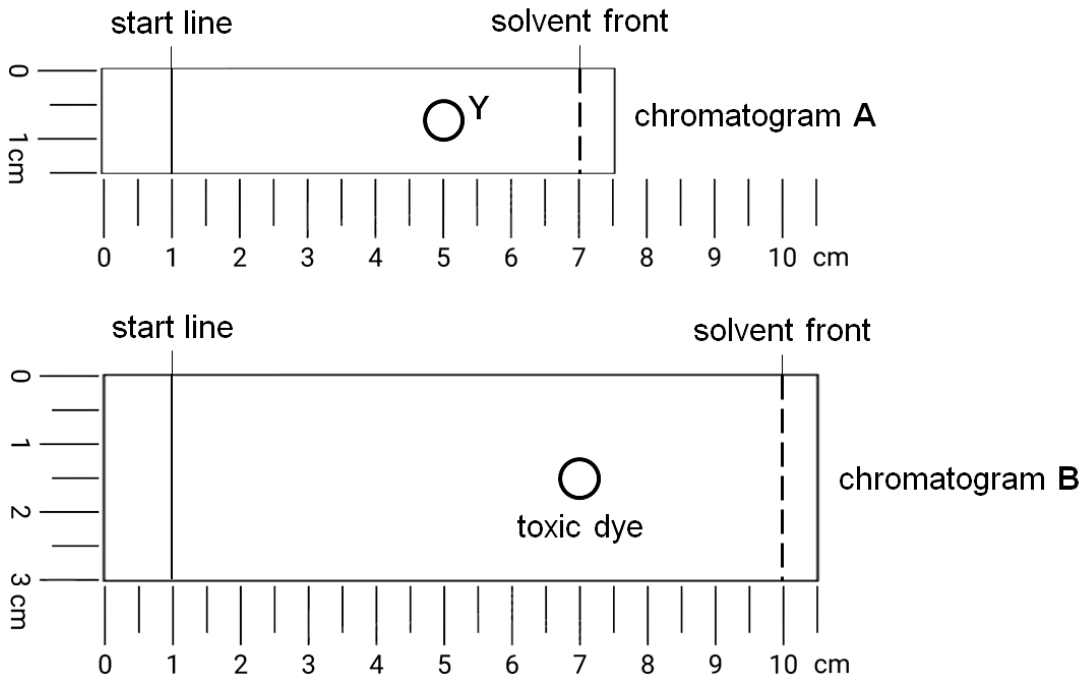
…… [1]

(b) Sketch the graph of temperature against total volume of distillate collected as the thermometer's reading increased from 50 °C to 85 °C.



[2]

Chromatography was carried out on substance **Y** and a toxic dye separately using water as the solvent. The results obtained are shown in chromatogram **A** and chromatogram **B** respectively.



(c) Determine the R_f value of substance **Y**. Show your working clearly and leave your answer to 2 decimal places.

…… [1]

(d) Does the toxic dye contain substance **Y**? Explain your answer.

…… [1]

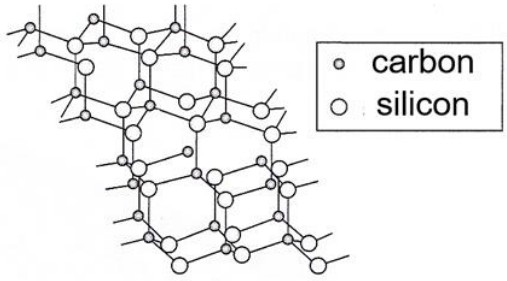
(e) When carrying out chromatography, explain briefly why the start line should be drawn with a pencil and not a pen.

……

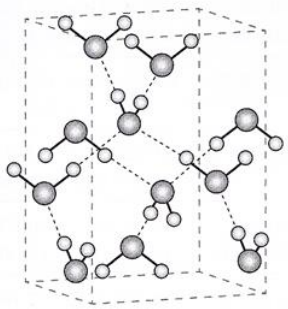
…… [1]

[Total: 6 Marks]

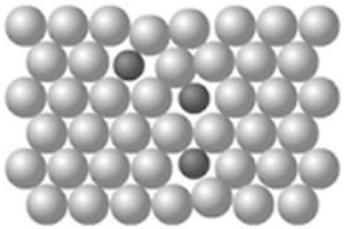
A3 The structure of five chemical substances are shown below.



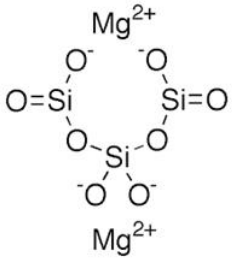
structure **I**



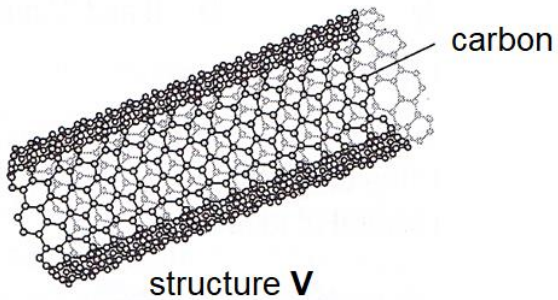
structure **II**



structure **III**



structure **IV**



structure **V**

(a) Which of the structure above is an element? ..... [1]

(b) Which of the structure(s) above melt over a range of temperatures?

..... [1]

(c) Which of the following structures is unable to conduct electricity in any state?

..... [1]

(d) State the type of particles present in structure **II** when it is in the gaseous state. Describe the arrangement and movement of those particles in the gaseous state.

.....

..... [2]

(e) In terms of bonding and structure, explain whether structure **IV** can conduct electricity in the solid state.

……

……

…… [2]

[Total: 7 Marks]

A4 During the extraction of copper, its sulfides are commonly blasted in furnaces with hot air to liberate sulfur dioxide gas as shown in the equation below.

$$Cu_2S + O_2 \rightarrow 2Cu + SO_2$$

(a) Describe a test that can be carried out to prove that the gas liberated is sulfur dioxide. Include any relevant observations.

……

…… [2]

(b) Is Cu_2S oxidised, reduced or both in the equation above? Explain your answer using oxidation numbers.

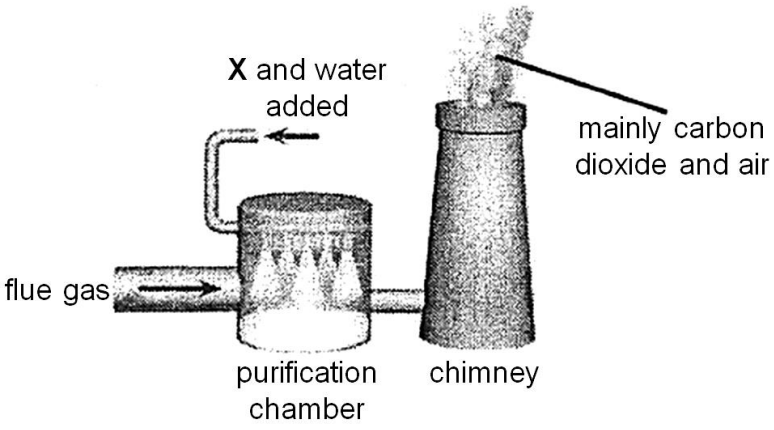
……

……

……

…… [3]

(c) The furnaces release flue gas that contains mainly air and sulfur dioxide. Since sulfur dioxide gas is harmful for the environment, it can be removed from the flue gas using a 'scrubber' that contains compound **X** and water.



Write a balanced equation to represent the removal of sulfur dioxide by **X**.

…… [1]

[Total: 6 Marks]

A5 Group II elements show similar trends in physical and chemical properties as Group I elements down the group. The trends of some properties of Group II elements are as shown.

Group II elements	Trends
Mg	Down Group II, 1. melting and boiling point decreases 2. reducing power …….. 3. ease of Group II carbonate decomposition decreases
Ca	
Sr	
Ba	

(a) Fill in the blank above with the most appropriate word. [1]

(b) Explain the trend in melting point down Group II in terms of bonding and structure.

……

……

…… [2]

(c) Predict what will be observed when barium is added to a beaker of water. Include observations from any relevant confirmation test(s) as well.

……

…… [2]

(d) Explain the trend in the ease of Group II carbonate decomposition.

……

…… [2]

(e) Can strontium be extracted from its oxide using carbon? Explain your answer.

……

…… [1]

(f) A student attempted to protect calcium metal from corrosion by attaching a piece of magnesium strip to it via a wire. Will her attempt be successful? Explain your answer.

……

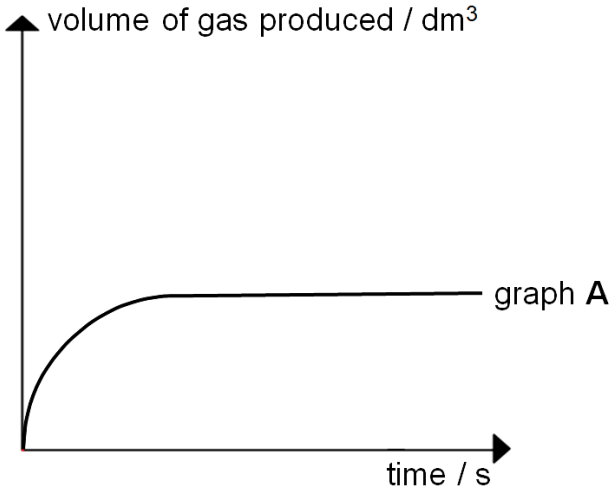
…… [2]

(g) Group II elements undergo exothermic reactions with Group VII halogens to form salts. State the chemical formula of the Group VII element that will have the most exothermic reaction with barium.

…… [1]

[Total: 11 Marks]

A6 Jason added 8.4 g of magnesium carbonate to 100 cm^3 of 1.0 mol/dm^3 dilute hydrochloric acid. The volume of gas liberated was measured against a fixed time interval and graph **A** was obtained.



(a) Calculate the volume of gas produced by the reaction and indicate the value in the graph above.

[2]

(b) Jason repeated the experiment using different acids while **keeping all the other conditions the same.**

(i) On the same diagram, sketch another graph of the reaction using ethanoic acid. Label this graph as **B**. [1]

(ii) On the same diagram, sketch another graph of the reaction using dilute sulfuric acid. Label this graph as **C**. [1]

(c) Explain the difference in the rate of reaction between graph **A** and graph **C** in terms of collision theory.

……

……

…… [2]

(d) Jason attempted to prepare a pure and dry sample of magnesium ethanoate. He added excess magnesium strips to ethanoic acid dissolved in ethanol. Will his attempt be successful? Explain your answer.

……

…… [1]

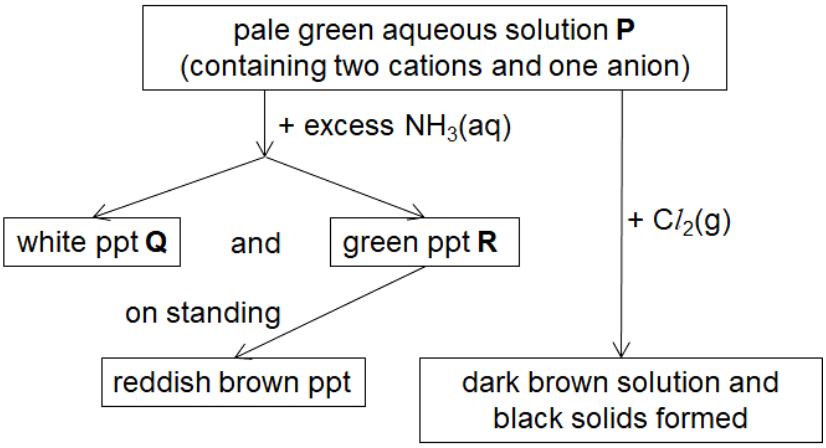
(e) Jason poured 1.0 mol/dm^3 of aqueous potassium hydroxide from a beaker into another beaker containing 1.0 mol/dm^3 of dilute nitric acid and heated the resulting mixture to dryness. However, he was unable to obtain a pure and dry sample of potassium nitrate. Suggest why and state a suitable method that he should have employed.

……

…… [2]

[Total: 9 Marks]

A7 The flow chart below shows a series of chemical tests involving solution **P**.



(a) What could be the chemical formula of the anion present in **P**?

…… [1]

(b) What could be the chemical formula of the cation present in **Q**?

…… [1]

(c) Write down the ionic equation, with state symbols, for the formation of precipitate **R**.

…… [2]

(d) What will be observed when excess zinc strips are added into solution **P**?

…… [1]

[Total: 5 Marks]

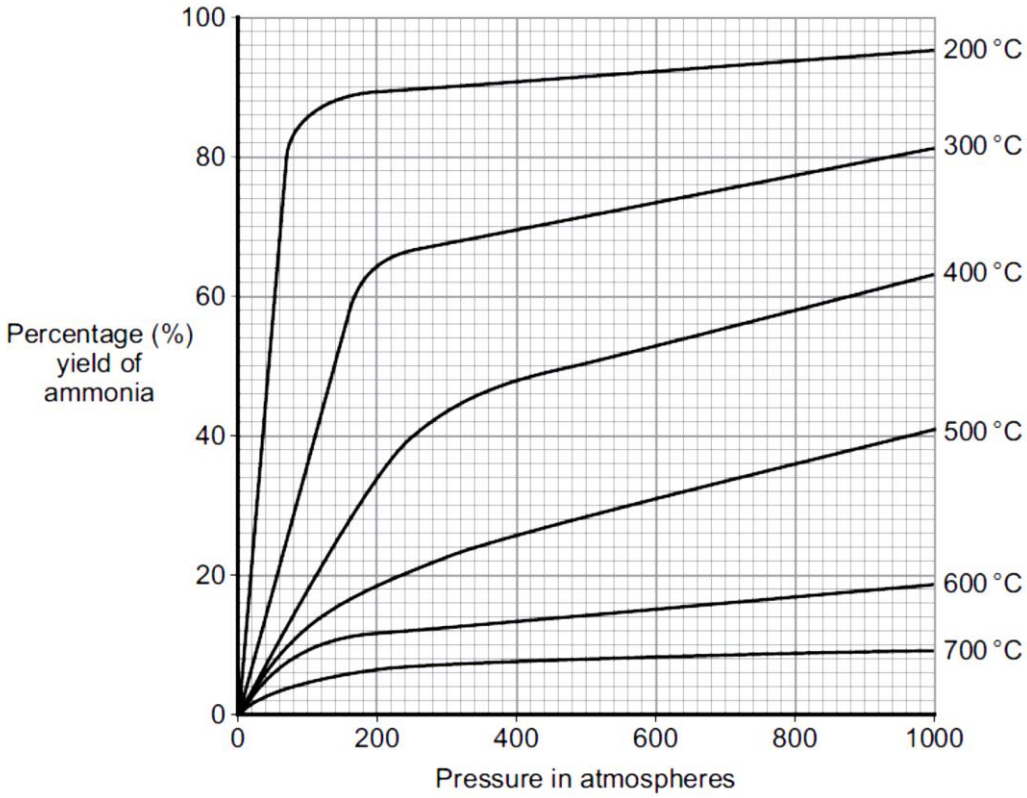
Section B

Answer all **three** questions in this section.
The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 The Haber process produces ammonia from the reaction between nitrogen and hydrogen. Finely divided iron is used as a catalyst to speed up the reaction.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ mol}^{-1}$$

The process can be carried out at various temperature and pressure to obtain different yields of ammonia as shown in the graph below.



(a) Based on the graph above, state all possible temperatures and pressures that can be applied to obtain a yield of 80%.

…… [2]

(b) Which set of conditions from **(a)** is more favourable? Support your answer with a good reason.

……

…… [1]

(c) Explain in terms of collision theory why the iron used is finely divided.

……

…… [2]

(d) If 4 moles of ammonia gas are produced from the Haber process, what is the energy change of this reaction? Show your working clearly.

[1]

(e) Nitrogen can also react with hydrogen to form hydrazine.

$$N_2 + 2H_2 \rightarrow N_2H_4$$

Draw the dot-cross diagram of hydrazine. Show only the valence electrons.

[2]

(f) Using the values of bond energies provided in the table below, calculate the enthalpy change of this reaction in (e).

bond	bond energy / kJ mol^{-1}	bond	bond energy / kJ mol^{-1}
H-H	436	N-N	163
N-H	391	N=N	418
		N≡N	944

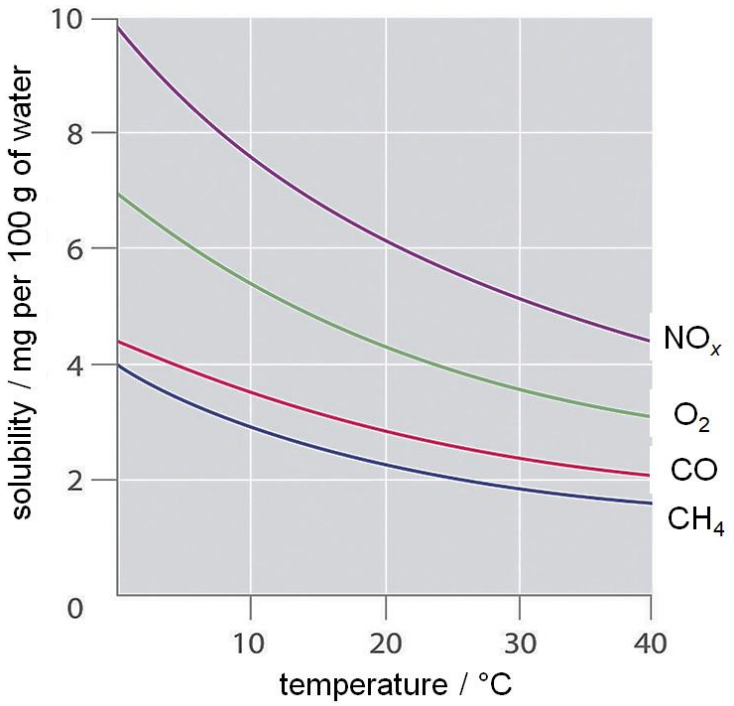
[2]

(g) Sketch a clearly labelled energy profile diagram for the formation of hydrazine.

[2]

[Total: 12 Marks]

B9 The solubility curve of four gases in 100 g of water are shown below. Both carbon monoxide and NO_x can be generated from the engines of motor vehicles. Oxygen is produced when plants carry out photosynthesis and methane is a greenhouse gas that is produced from the decomposition of organic matter.



(a) Estimate the solubility of methane gas in 200 g of water at 25 °C.

…… [1]

(b) The percentage by mass of nitrogen in NO_x is 46.7 %, determine the value of *x*. Show your working clearly.

[2]

(c) Why is it important to minimise the amount of NO_x in our atmosphere?

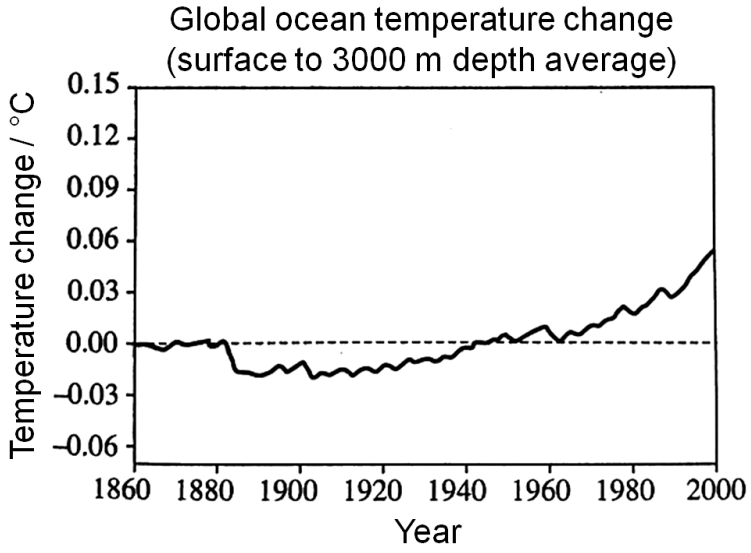
……

…… [2]

(d) Motor vehicles are now capable of removing both carbon monoxide and nitrogen monoxide. Provide a balanced chemical equation to show how they are removed.

…… [1]

(e) The global ocean temperature change graph is shown below.



Based on the trend of this graph and the solubility curve, predict what could happen to the amount of dissolved oxygen in our oceans after the year 2000. As a result, suggest a possible negative impact on marine life.

……

…… [2]

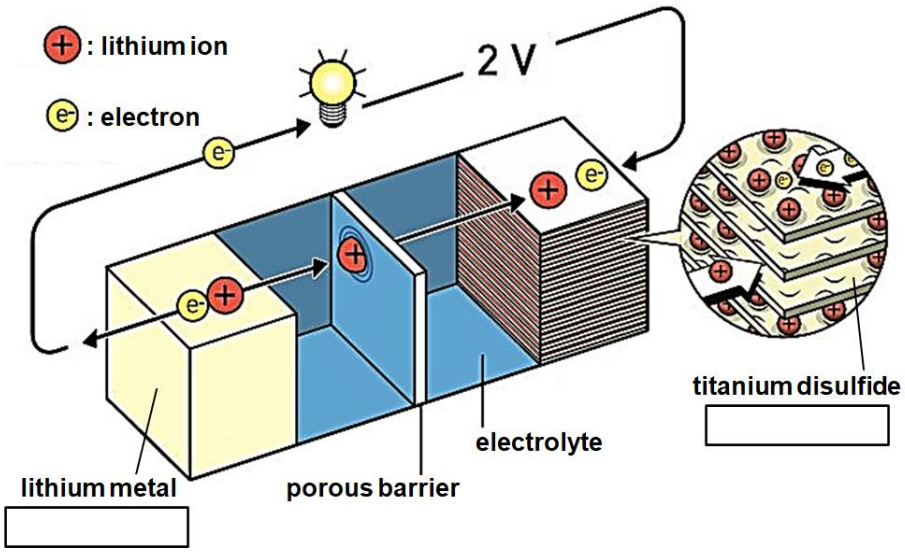
[Total: 8 Marks]

B10 EITHER

The Nobel Prize in Chemistry 2019 was awarded to John B. Goodenough, M. Stanley Whittingham and Akira Yoshino for their contributions to the development of the lithium-ion battery. This rechargeable battery laid the foundation for wireless electronics such as mobile phones and laptops. It also makes a fossil fuel-free world possible, as it is used for everything from powering electric cars to storing energy from renewable sources.

The initial design of Whittingham's lithium-ion battery is shown below. It consists of lithium ions that were stored in spaces between layers of titanium disulfide.

When the battery was used to operate an electronic equipment, electrons flowed from lithium metal to titanium disulfide. When recharging the battery, lithium ions flowed back to the metal.



(a) In the empty boxes above, label the anode and cathode clearly, include the "+"and "–" sign to show where the positive and negative terminals are when the battery is discharging. [2]

(b) In the past, nickel-cadmium batteries were commonly used to operate laptops. Thanks to the development of lithium-ion batteries, the production of lighter laptops is now possible. Suggest why.

……

…… [1]

(c) Yoshino replaced the lithium metal with a mixture of coke and lithium to make the battery much safer to use.

The reaction that occurs at the mixture is: $LiC_6 \rightarrow C_6 + Li^+ + e^-$

Goodenough further improved on the model by replacing titanium disulfide with cobalt(IV) oxide, which changed the voltage of the battery from 2 Volts to 4 Volts.

The reaction that occurs at cobalt(IV) oxide is: $CoO_2 + Li^+ + e^- \rightarrow LiCoO_2$

(i) Is titanium disulfide or cobalt(IV) oxide a stronger oxidising agent? Support your answer based on the information given.

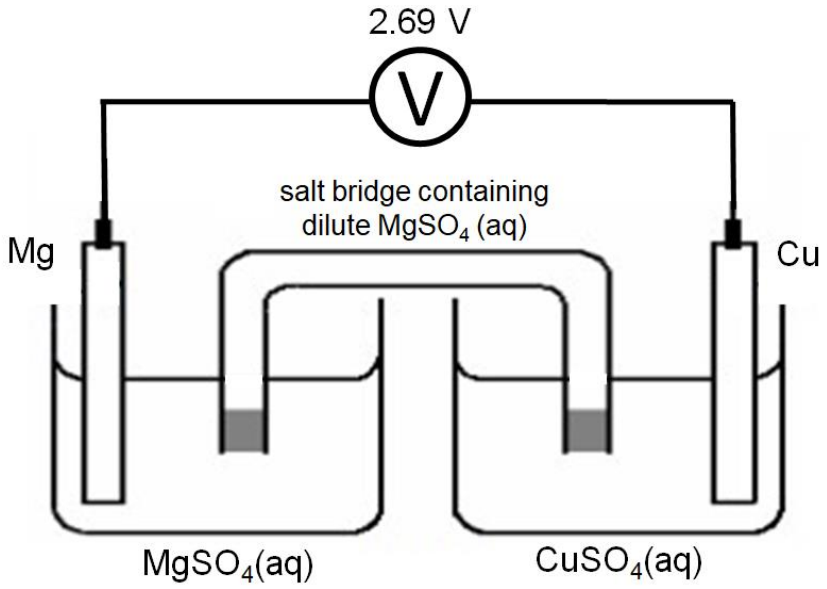
……..

……... [2]

(ii) Construct an overall equation for the improved battery.

……... [1]

(d) A simple cell constructed from the laboratory using magnesium and copper is shown below.



(i) Describe what will be observed at the anode and cathode when the voltmeter is replaced with a light bulb.

Anode: ……

Cathode: …… [2]

(ii) Provide **two** disadvantages of using the magnesium-copper simple cell as compared to the use of the lithium - cobalt(IV) oxide battery.

……...

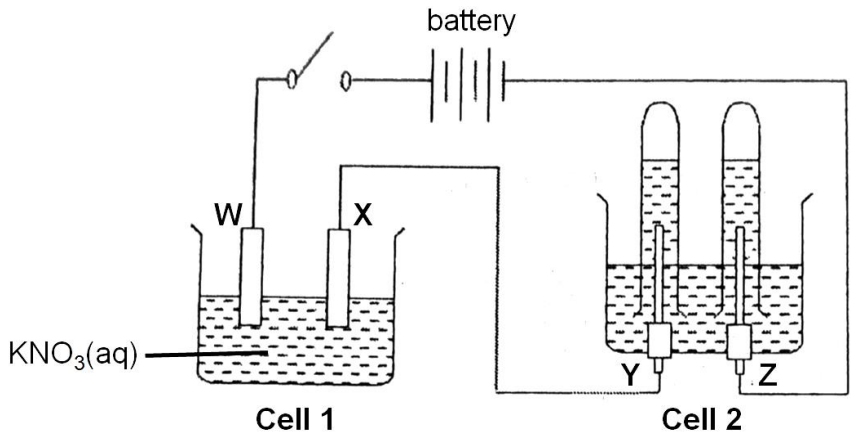
……... [2]

[Total: 10 Marks]

B10 OR

Cells **1** and **2** were set up using four electrodes and two different electrolytes. Electrodes **W** and **X** are made up of graphite while electrodes **Y** and **Z** are made up of platinum. The electrolyte in **Cell 1** is aqueous potassium nitrate.

The switch was closed for a while and the following results were obtained as shown below.



(a) Suggest a possible electrolyte used in **Cell 2.**

…… [1]

(b) Write the half equation for the reaction that occurred at the anode of **Cell 1**.

…… [1]

(c) If the volume of gas collected at **Y** is 2.4 dm^3, what is the number of moles of electrons that passed through **X**? Show your working clearly.

[2]

(d) If electrode **W** is replaced with a copper electrode **V**, write down two observations in **Cell 1** after the switch in the circuit is closed for a long time.

……

…… [2]

(e) The electrolyte in **Cell 1** is replaced with aqueous silver nitrate and a series of electrolytic experiments were carried out using graphite electrodes to determine how various factors affect the mass of silver deposited at the cathode.

The following results were obtained.

experiment	duration (s)	current through electrolyte (A)	concentration of electrolyte (mol/dm^3)	mass of silver deposited (g)
1	100	9.65	1.0	0.108
2	100	9.65	0.5	0.108
3	200	9.65	0.5	0.216
4	100	19.30	1.0	0.216

(i) Which two experiments should be used to determine the relationship between concentration of electrolyte and the mass of silver deposited?

…….. [1]

(ii) From the results above, identify two factors that affect the mass of silver deposited and describe their relationships.

……..

…….. [2]

(iii) Determine the mass of silver deposited when a current of 19.30 A is passed through the 1.5 mol/dm^3 of electrolyte for 50 s.

…….. [1]

[Total: 10 Marks]

End of Paper