BEATTY SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2022
SECONDARY FOUR EXPRESS

CANDIDATE NAME			
CLASS		REGISTER NUMBER	

CHEMISTRY **6092/02**

Paper 2 **19 August 2022**

Setter: Mr Yeo Chee Keong **1 hour 45 minutes**

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions. The last question is in the form either/or.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 20.

The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use	
A	**50**
B7	**12**
B8	**8**
B9…	**10**
Total	**80**

Section A

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

A1 Use the list of substances to answer the questions.

You may use each substance once, more than once or not at all.

iodine

ozone

dichloroethane

magnesium

potassium manganate(VII)

copper(II) sulfate

calcium chloride

diamond

(a) Which substance is a good reducing agent?

.... [1]

(b) Which substance can be formed under ultraviolet radiation conditions?

.... [1]

(c) Which substance exists as three different colours when the physical state is changed?

.... [1]

(d) Which **two** substances can react to undergo a redox reaction?

.... [1]

(e) Which substances are elements?

.... [1]

[Total: 5]

A2 Lithium is a metal with low melting point and low density. It can react with cold water to form lithium hydroxide and hydrogen gas.

(a) Write a chemical equation for the reaction of lithium with cold water.

.... [1]

(b) Given that 0.2 g of lithium metal was used in the reaction with an excess of cold water, determine the volume of hydrogen gas produced.

[2]

(c) Describe how you can determine that the reaction has reached completion.

....

.... [1]

[Total: 4]

A3 Hydrochloric acid reacts with methanol to form chloromethane and water in the equation as shown.

$$HCl(aq) + CH_3OH(aq) \rightarrow CH_3Cl(g) + H_2O(l)$$

(a) Briefly describe a practical method by which the concentration of hydrochloric acid can be determined in a sample.

....

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....

....

....

....

....

....

.... [3]

(b) Fig. 3.1 shows how the concentration of hydrochloric acid changes as the reaction proceeds.

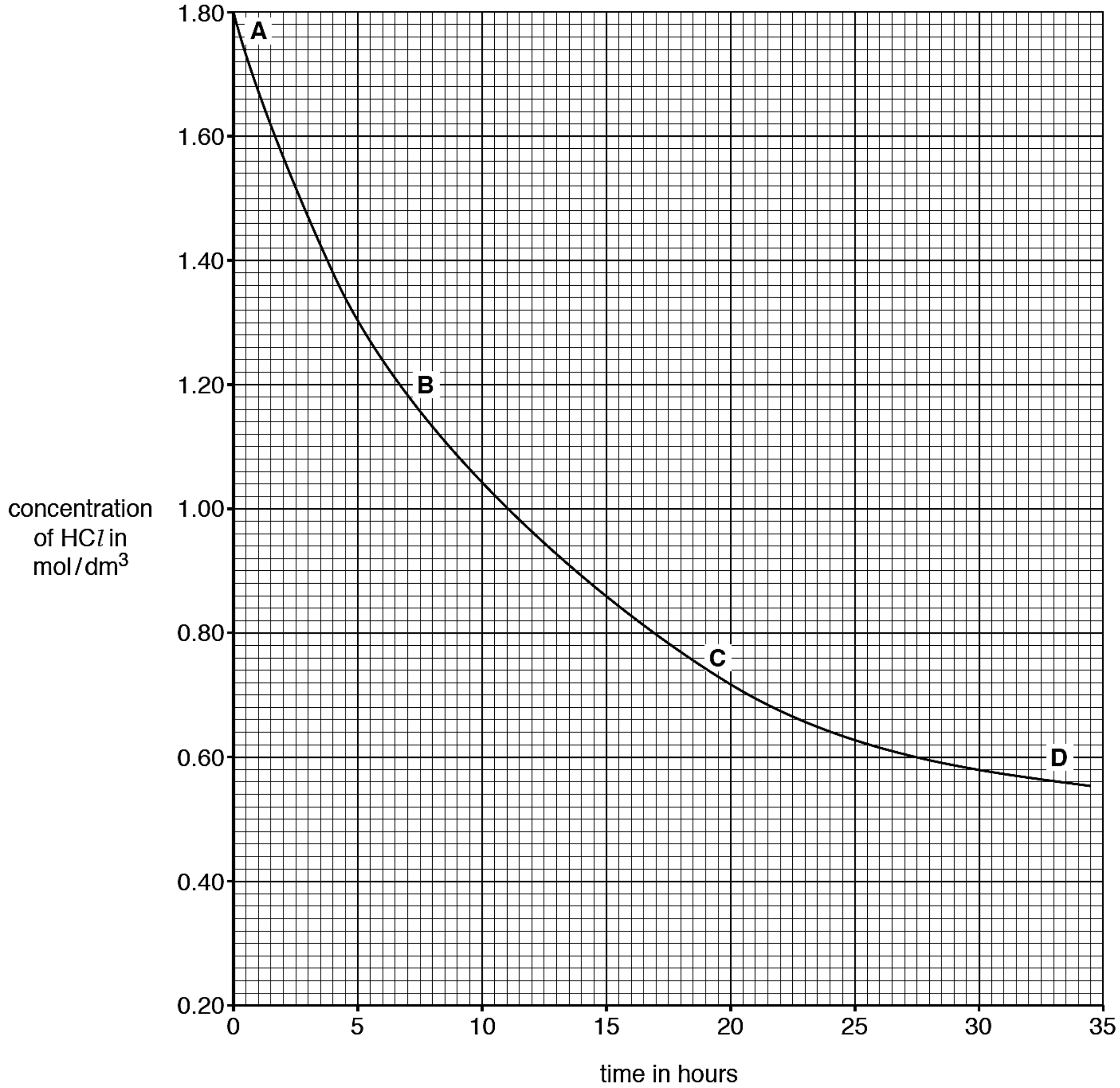


Fig. 3.1

(i) Deduce the concentration of hydrochloric acid 4 hours from the start of the experiment.

concentration = ... mol/dm^3 [1]

(ii) With reference to the graph in Fig. 3.1, explain clearly whether hydrochloric acid or methanol is the limiting reactant.

....

....

.... [2]

(iii) Explain why point **A** in Fig. 3.1 has the fastest rate of reaction.

.... [1]

(iv) Enriq thinks that the average rate of the reaction can be determined by the formula as shown:

$$\left(\frac{\text{rate at point } \mathbf{A} + \text{rate at point } \mathbf{B} + \text{rate at point } \mathbf{C} + \text{rate at point } \mathbf{D}}{4}\right)$$

Do you agree with Enriq? Explain your answer.

....

....

.... [2]

(c) The rate of formation of chloromethane and water can be changed by altering some conditions.

(i) Draw on Fig. 3.1, the curve that you would expect if the experiment was repeated with hydrochloric acid at a higher temperature.

[1]

(ii) Use ideas about collisions between particles to describe and explain how the rate of a reaction changes when the concentration of hydrochloric acid is increased.

....

....

....

.... [2]

(iii) Use kinetic particle theory to explain why increasing the pressure of the reaction chamber has little or no effect on the rate of reaction.

....

....

.... [2]

[Total: 14]

A4 Hydrogen is an important source of fuel as it burns cleanly and has a high energy content per unit mass. Hydrogen can be produced from the steam-methane reforming reaction shown in Step 1.

Step 1: $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \quad \Delta H = +206$ kJ/mol

The carbon monoxide produced can undergo water-gas shift reaction to produce more hydrogen shown in Step 2.

Step 2: $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g) \quad \Delta H = –41.0$ kJ/mol

(a) Based on **Step 1** and **Step 2**, write the overall equation for the production of hydrogen gas. Include the overall enthalpy change.

.... [2]

(b) Give **two** reasons why it is better to produce hydrogen using both steps of the reaction in **(a)** than using **Step 1** alone. Explain your answer clearly.

....

....

....

....

.... [4]

(c) Another method of hydrogen production is through the electrolysis of pure water as shown.

$$2H_2O(l) \rightarrow O_2(g) + 2H_2(g) \quad \Delta H = +484 \text{ kJ/mol}$$

However, this electrolytic process takes place very slowly. Explain why the reaction takes place very slowly and suggest a modification to make the reaction proceed faster.

explanation ....

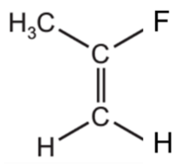
....

modification ....

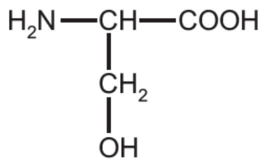
.... [2]

[Total: 8]

A5 The diagram shows two organic molecules, **A** and **B** which can undergo polymerisation.



A



B

(a) State the type(s) of polymerisation that both molecules can undergo.

molecule **A** ....

molecule **B** .... [2]

(b) Draw the structure of **two** repeating units when molecule **A** undergoes polymerisation.

[1]

(c) Suggest why polymers made from molecule **B** show a wider range of properties than polymers made from molecule **A**.

....

....

.... [2]

[Total: 5]

A6 Ethanol can be manufactured by the hydration of steam with ethene and the fermentation of glucose solution. Table 6.1 shows a comparison of both methods producing ethanol.

Table 6.1

method	fermentation	hydration
raw material	glucose	ethene
reaction	$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$	$C_2H_4 + H_2O \rightleftharpoons C_2H_5OH$
operating pressure	1 atm	60 to 70 atm
type of process	batch (stop-start)	continuous (runs all the time)

(a) State the source of the raw materials used for both methods.

source of glucose ....

source of ethene .... [1]

(b) With reference to Table 6.1, suggest one reason why hydration is preferred over fermentation to produce ethanol.

....

.... [1]

(c) Table 6.2 shows the amount of ethanol formed when one mole of ethene reacts with one mole of steam under different conditions.

Table 6.2

temperature / °C	pressure / atm	amount of ethanol / mol
250	50	0.420
300	50	0.400
300	60	0.460
300	70	0.550
350	50	0.380

(i) Describe the effect of temperature changes on the amount of ethanol formed.

....

.... [1]

(ii) Hence, explain why the optimum temperature of 300 °C was used.

....

.... [1]

(iii) High pressures of up to 200 atm were **not** used in the reaction as an unwanted product may be formed.

Name this unwanted product.

.... [1]

(iv) Given that 40 g of ethene was used, calculate the actual **number of moles** of ethanol formed and the **percentage yield** for the reaction conditions occurring at 300 °C and 70 atm.

[2]

(d) Peihao claims that the hydration of ethene with steam is an exothermic reaction.

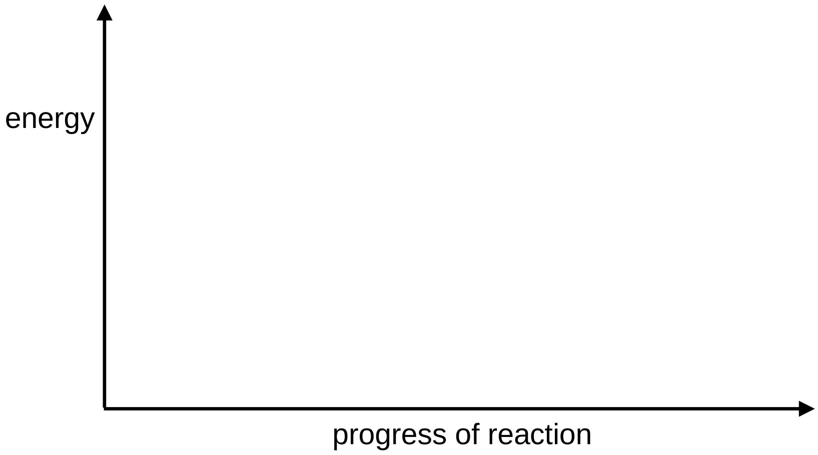
Do you agree with him? Use the bond energies in Table 6.3 to justify your answer.

Table 6.3

bond	bond energy, in kJ/mol	bond	bond energy, in kJ/mol
H − H	436	C − O	358
O − H	463	C − H	412
C = C	612	C − C	348

.... [3]

(e) Draw the energy profile diagram for the reaction in **(d)**. Label on the diagram the activation energy and the enthalpy change.



[3]

(f) Draw a structural isomer of ethanol.

[1]

[Total: 14]

Section B

Answer all **three** questions in this section.

The last question is in the form of an either/or question and only one of the alternatives should be attempted.

B7 Properties of Transition Metals

Transition metals have similar properties like main group (Group I and II) metals. In addition, transition metals exhibit variable oxidation states, form coloured compounds and their compounds can be used as catalysts.

<u>Variable Oxidation States</u>

As d-block elements in Period 3, transition metals can hold up to 18 electrons in the third electron shell. Beyond argon (2,8,8), the electronic configuration of Period 4 elements require the knowledge of the orbital theory. Specifically, Period 4 elements' electronic configuration would be represented by d-orbitals (3d) and s-orbitals (4s).

4s orbitals are lower in energy than 3d orbitals, hence electrons occupy the 4s orbitals before the 3d orbitals. The s-orbitals can hold a maximum of two electrons while the d-orbitals can hold a maximum of ten electrons.
An illustration of the electronic configuration of scandium is shown below.

number of electrons in the orbital

$$[Ar]4s^{2}3d^{1}$$

electron shells

Electronic configuration of argon (2,8,8) is simplified as [Ar], where [Ar] represent 18 electrons.

The electronic configuration of some elements in Period 4 are shown in Table 7.1.

Table 7.1

proton number	element	electronic configuration
19	potassium	$[Ar]4s^{1}$
20	calcium	$[Ar]4s^{2}$
21	scandium	$[Ar]4s^{2}3d^{1}$
22	titanium	$[Ar]4s^{2}3d^{2}$
23	vanadium	$[Ar]4s^{2}3d^{3}$
24	chromium	
25	manganese	$[Ar]4s^{2}3d^{5}$
26	iron	
27	cobalt	
30	zinc	$[Ar]4s^{2}3d^{10}$

Transition metals can have variable oxidation states due to the loss of electrons in the 4s and 3d orbitals. For example, titanium can have variable oxidation states of +1, +2, +3 and +4 from the loss of electrons from the 4s and 3d orbitals.

Coloured Compounds

Transition metals form coloured compounds. This is due to several reasons. First, the five d-orbitals split into two different energy levels when a compound is formed as shown in Fig. 7.1.

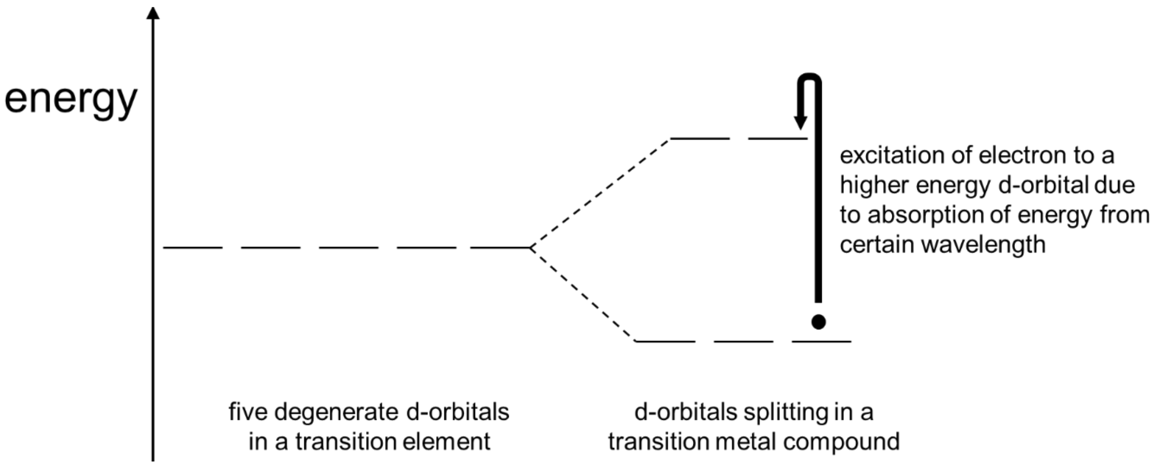
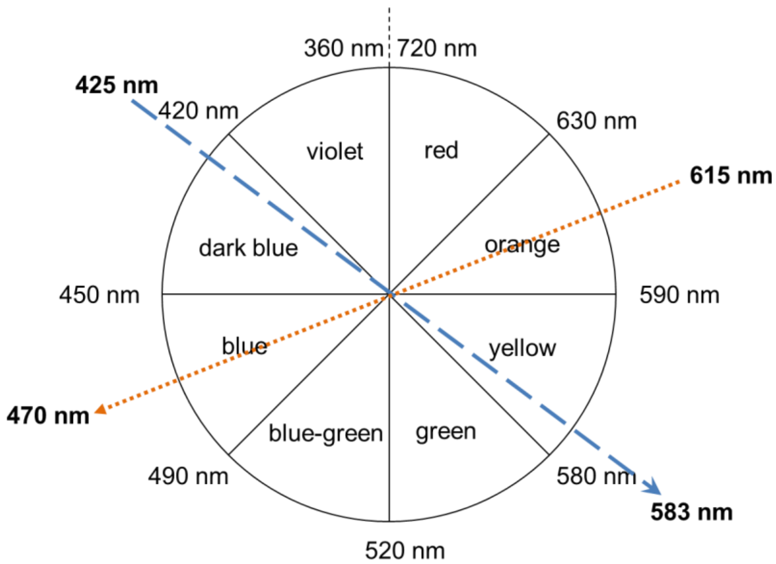


Fig. 7.1

Second, the electron in the lower energy d-orbitals absorbs a certain wavelength of light within the visible region of the electromagnetic spectrum and is excited (moved) to a higher energy level of the **empty or partially filled d-orbital** as shown in Fig. 7.1.

Third, the **colour observed** by our eyes is the **complement of the colour absorbed.** Fig. 7.2 shows the wavelengths absorbed by the different compounds of iron and copper and the colour observed.



solutions	wavelength absorbed (colour)	wavelength observed (colour)
copper(II) compound	615 nm (orange)	470 nm (blue)
iron(III) compound	425 nm (dark blue)	583 nm (yellow)

Fig. 7.2

One example illustrated in Fig. 7.2 would be that some solutions of copper(II) compound absorbed wavelengths at around 615 nm (orange colour) and the wavelengths observed are at around 470 nm (blue colour), which is observed by us as blue solutions.

<u>Catalytic properties</u>

Transition metals and their compounds are good catalysts as they provide a binding site for the reactants to react. This helps to increase the rate of reaction.
The catalysed conversion of sulfur dioxide to sulfur trioxide using vanadium(V) oxide in the two-step reaction is shown.

Step 1: $V_2O_5 + SO_2 \rightarrow V_2O_4 + SO_3$
Step 2: $2V_2O_4 + O_2 \rightarrow 2V_2O_5$

(a) With reference to Table 7.1, write the electronic configuration of iron and cobalt.

electronic configuration of Fe ....

electronic configuration of Co .... [2]

(b) **(i)** State all the possible oxidation states that vanadium can have.

.... [1]

(ii) Is it possible for manganese to have an oxidation state of +8? Explain your answer.

....

.... [1]

(c) **(i)** A sample solution **Z** absorbs a wavelength of around 680 nm.

With reference to Fig. 7.2, state the **colour** of wavelength **absorbed** by solution **Z**.

.... [1]

(ii) Nickel(II) chloride solutions absorb a wavelength of around 395 nm.

With reference to Fig. 7.2, state the **colour** of wavelength **observed** from a solution of nickel(II) chloride.

.... [1]

(iii) With reference to Fig. 7.1 and Fig. 7.2, explain why nickel is able to form coloured compounds when reacted with chlorine.

....

....

....

....

....

.... [3]

(d) Zinc is a Period 3 transition metal with the electronic configuration $[Ar]4s^2 3d^{10}$. However, solutions of zinc compounds are colourless.

With reference to the data given, explain why solutions of zinc compounds appear colourless.

…………………………………………………………………………………………………….

………………………………………………………………………………………… [1]

(e) **(i)** Explain how the conversion of sulfur dioxide to sulfur trioxide shows that vanadium(V) oxide acts a catalyst.

……………………………………………………………………………………………

………………………………………………………………………………….. [1]

(ii) Briefly explain how a catalyst increases the rate of reaction.

……………………………………………………………………………………………

………………………………………………………………………………….. [1]

[Total: 12]

B8 Fig. 8.1 shows the carbon dioxide concentration in the atmosphere in the Northern Hemisphere between 1965 and 2014.

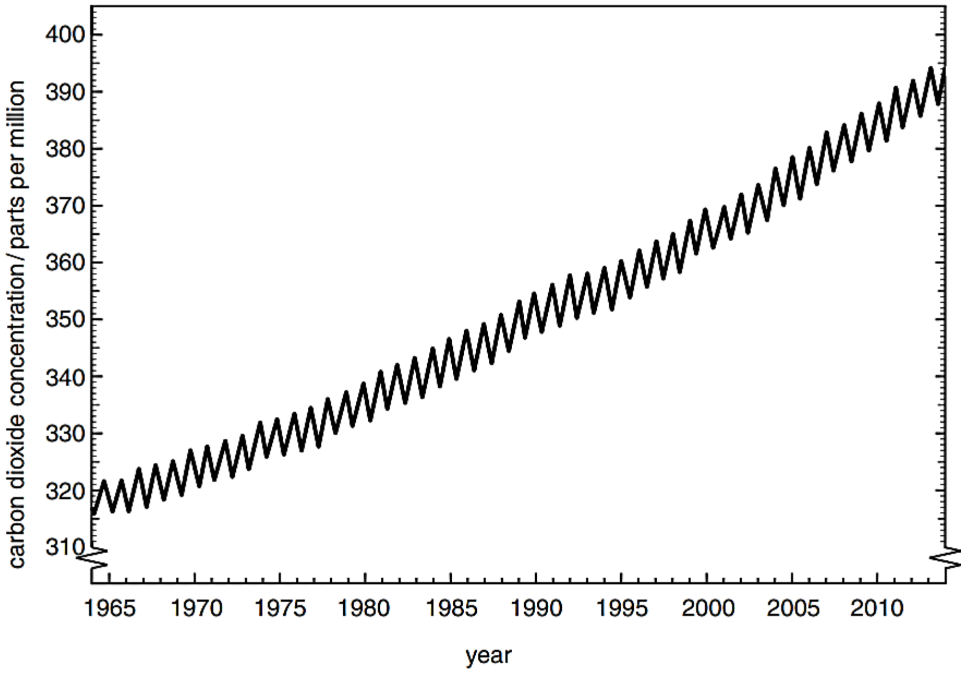


Fig. 8.1

(a) **(i)** Describe the general trend observed in Fig. 8.1.

.... [1]

(ii) Explain the changes in the carbon dioxide concentration over the 50-year period observed in **(a)(i)**.

....

....

.... [2]

(iii) The concentration of carbon dioxide **varies within the year**, where the lowest concentration of carbon dioxide was observed during summer times in June, and the highest concentration of carbon dioxide observed during winter times in December.

Describe and explain the trend observed **within each year**.

....

....

....

....

....

.... [3]

(b) **(i)** Explain why it is important to regulate the concentration of carbon dioxide in the atmosphere.

....

....

.... [1]

(ii) State one effect brought about by the high concentrations of carbon dioxide.

....

.... [1]

[Total: 8]

EITHER

B9 Wayne sets up a simple electric cell experiment shown in Fig. 9.1.

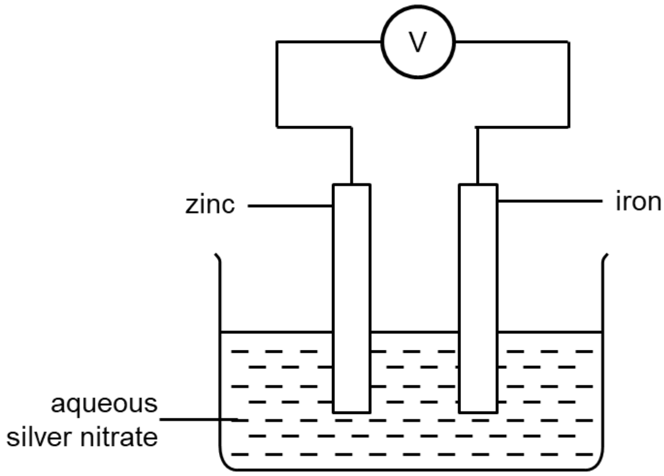


Fig. 9.1

(a) Use your knowledge of energy conversion to explain why the simple electric cell in Fig. 9.1 is also known as a potable battery.

………………………………………………………………………………………………….

……………………………………………………………………………………… [1]

(b) Write ionic equations for reaction at each electrode.

positive electrode …………………………………………………………………………

negative electrode ...…………………………………………………………………… [2]

(c) A small amount of grey deposit was observed at the bottom of the beaker.

Explain this phenomenon observed.

………………………………………………………………………………………………….

………………………………………………………………………………………………….

……………………………………………………………………………………… [2]

(d) Skyler thinks that replacing the same number of moles of zinc metal with magnesium metal will increase only the rate but **not** yield of the product.

Do you agree? Explain your answer.

………………………………………………………………………………………………….

………………………………………………………………………………………………….

……………………………………………………………………………………… [2]

(e) Other than the small amount of grey deposit obtained, Wayne claims that his experiment setup is the best way to coat silver onto the iron object.

Suggest one reason this method of coating is **not** cost-effective.

……………………………………………………………………………………………….

…………………………………………………………………………………………… [1]

(f) Draw another experiment setup that can efficiently coat the iron object with silver.

[2]

[Total: 10]

OR

B9 Table 9.1 shows the melting points of some compounds formed with Period 3 elements.

Table 9.1

compound	melting point / °C	compound	melting point / °C	compound	melting point / °C
sodium fluoride	990	sodium oxide	1130	sodium chloride	808
magnesium fluoride	1260	magnesium oxide	2850	magnesium chloride	715
aluminium fluoride	1290	aluminium oxide	2070	aluminium chloride	190
silicon tetrafluoride	−90	silicon dioxide	1710	silicon tetrachloride	−68

(a) Jie Xi thinks that the type of anion affects the melting point of the **metallic compounds** formed.

Do you agree with her? Use the information in Table 9.1 to describe any trends observed and the attractive forces between particles to explain your answer.

....

....

....

....

....

....

....

.... [3]

(b) **(i)** Theoretically, a more reactive metal forms stronger ionic bonds in its compounds. Explain why this statement is true.

....

.... [1]

(ii) Is the theory in **(b)(i)** applicable to the compounds listed in Table 9.1? Use the information in Table 9.1 to support your answer.

....

.... [1]

(c) **(i)** Draw a 'dot-and-cross' diagram for silicon tetrachloride.

Show outer electrons only.

[2]

(ii) With reference to the structure and bonding, explain the difference in the melting points of silicon dioxide and silicon tetrachloride.

....

....

....

....

.... [3]

[Total: 10]

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
				Key			1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9			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.).