Candidate Number

Anglo-Chinese School (Independent)

Year 4 Express
Preliminary Examination 2021

CHEMISTRY **6092/2**

PAPER 2

Tuesday 17th August 2021 1 hour 45 minutes

Additional materials:
Calculator

INSTRUCTIONS TO CANDIDATES

Write your candidate number in the box at the top of this page and on any separate answer paper used.

Section A

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

Section B

Answer all **three** questions in the spaces provided.
The last question is in the form of **EITHER / OR** and **only one** alternative should be attempted.

At the end of the examination, hand up the paper in one bundle.

INFORMATION FOR CANDIDATES

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 23.

You may use a calculator.

FOR EXAMINER'S USE	
Section A	
B9	
B10	
B11	
significant figures	
units	
TOTAL	

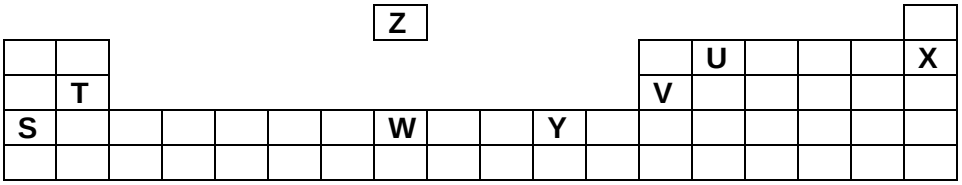
This question paper consists of 23 printed pages.

Section A

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

The total mark for this section is 50.

A1 The diagram shows part of the Periodic Table. Use the letters **S**-**Z** to answer the questions below. **S**-**Z** does not represent the symbols of the actual elements.



(a) Which element exists as a solid at r.t.p, has low density and floats on water? [1]

(b) Which element shows both metallic and non-metallic character? [1]

(c) Which elements are transition elements? [1]

(d) State two characteristic properties of transition elements. [2]

(e) Which gaseous element is likely to remain as a monoatomic substance? [1]

A2 The reaction between nitrogen and hydrogen to form ammonia is a reversible reaction as shown below.

forward reaction :	$N_2\ (g) + 3H_2\ (g) \rightarrow 2NH_3\ (g)$	$\Delta H = -92$ kJ/mol
backward reaction :	$2NH_3\ (g) \rightarrow N_2\ (g) + 3H_2\ (g)$	$\Delta H = +92$ kJ/mol

In order to determine the most cost-effective way to produce ammonia, a chemist Fritz Haber did a series of experiments to determine the yield of ammonia at different conditions.

temperature / ^oC	**pressure / atm**		
	300	400	500
400	48% NH_3	55% NH_3	61% NH_3
500	26% NH_3	32% NH_3	38% NH_3
600	13% NH_3	17% NH_3	21% NH_3

(a) Using the information given, state the conditions needed to produce the highest yield of ammonia. [1]

(b) Explain why the Haber Process is carried out at only 250 atm. [1]

(c) Suggest a possible explanation why it is ideal to remove ammonia as quickly as possible after it is formed. [1]

A3 An element **M** with a relative atomic mass of 152.4 exist in three isotopic forms as shown below.

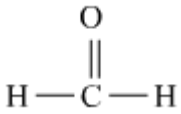
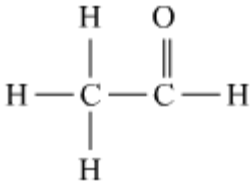
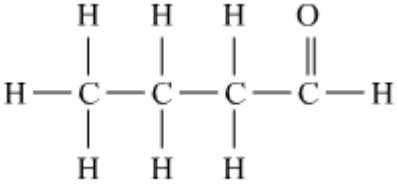
isotope	^{150}**M**	^{155}**M**	^{157}**M**
isotopic abundance	60 %	**X** %	**Y** %

(a) Define isotopes. [2]

(b) Determine, using calculations, the values of **X** and **Y**. [2]

(c) Given that ^{40}Ar, ^{40}K and ^{40}Ca are isobars. Using the information provided, explain what isobars are. [1]

A4 Aldehyde is a homologous series that contains the CHO functional group. Aldehydes can be obtained through the controlled oxidation of alcohols. More information about the aldehyde homologous series can be seen in the table below.

name of aldehyde	condensed formula	displayed formula	boiling point / °C
methanal	HCHO		- 19
ethanal	CH_3CHO		20
propanal	C_2H_5CHO		49
butanal	C_3H_7CHO		75

(a) Draw the displayed formula of propanal in the table above. [1]

(b) Write the general formula of the aldehyde homologous series. [1]

(c) Pentanal is a five-carbon aldehyde. Predict the boiling point of pentanal. [1]

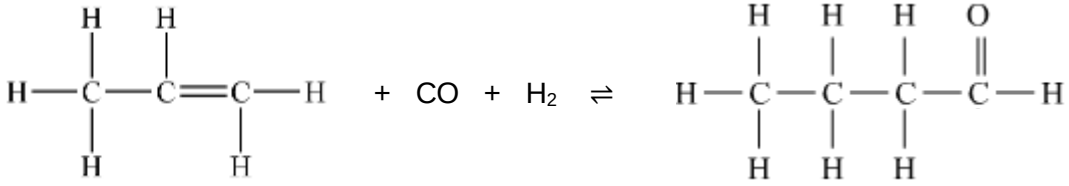
(d) Butanal has a molecular formula of C_4H_8O. It can exist as several isomers.

(i) Explain what isomers are. [1]

(ii) Draw the displayed formula of an isomer of butanal. [1]

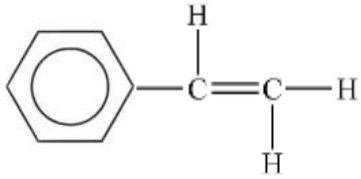
(e) Explain why the boiling point of aldehydes increases down the homologous series. [2]

(f) Hydroformylation is an industrial process to produce aldehydes from alkenes. This chemical reaction involves the addition of carbon monoxide gas and hydrogen gas at a temperature of 120°C and a pressure of 40 atm. An example of the hydroformylation can be seen below.



propene butanal

Styrene is the monomer used to produce polystyrene which is commonly used in foam food packaging. The structure of styrene is shown below.



(i) Styrene also undergoes hydroformylation. Draw the displayed formula of the product formed as a result. [1]

(ii) The product formed in **(f)(i)** is further oxidized to form compound **X**. compound **X** is able to react with magnesium to form a gas. Draw the structure of compound **X**. [1]

A5 The following gases are found in the atmosphere and they have different effects on the environment.

A	carbon dioxide
B	carbon monoxide
C	chlorofluorocarbon
D	chlorine monoxide
E	nitrogen dioxide
F	oxygen

(a) Use the letters **A** to **F** to answer the following questions.

(i) Which two gases combine together to form a substance responsible for global warming? [1]

(ii) Which gaseous pollutants, produced in the internal combustion engine of a car, are removed effectively by the catalytic converter? [1]

(iii) Which gases are responsible for the formation of acid rain? [1]

(b) A particular chlorofluorocarbon contains 41.5% by mass of chlorine and 44.4% by mass of fluorine. Given that the molar mass is 171 g/mol, determine the empirical formula and molecular formula of chlorofluorocarbon. [3]

(c) The destruction of the ozone layer by chlorofluorocarbon takes place via a three-step mechanism. Step **1** involves the breaking of the covalent bond between a carbon atom and chlorine atom in a chlorofluorocarbon in the presence of ultraviolet light. The equation below shows step 1 of the mechanism involving the chlorofluorocarbon CCl_2F_2.

Step **1** : $CCl_2F_2 \rightarrow CClF_2 + Cl$

Step **2** of the mechanism involves the chlorine atom formed from a chlorofluorocarbon attacking an ozone molecule to form chlorine monoxide and oxygen gas. This is shown in the equation below.

Step **2** : $Cl + O_3 \rightarrow ClO + O_2$

In the third step, the chlorine monoxide molecule produced reacts with an ozone molecule to produce oxygen gas and a chlorine atom.

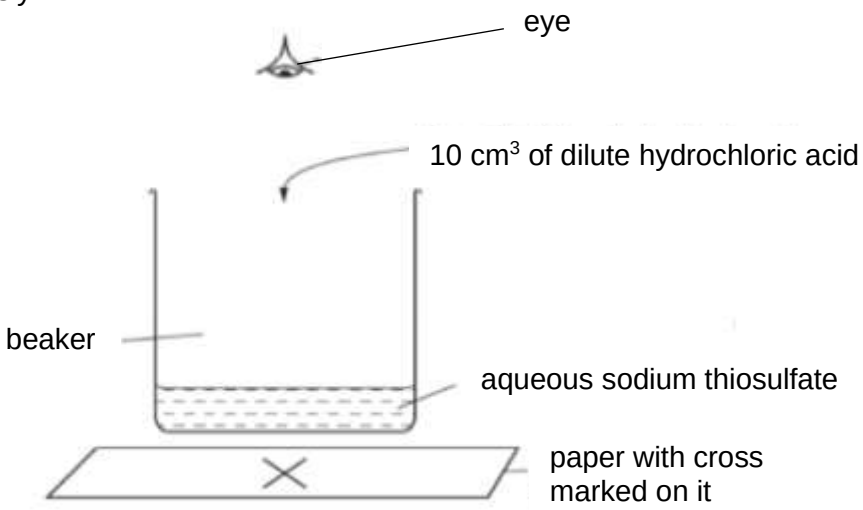
(i) Construct a balanced chemical equation for this reaction. [1]

(ii) Using your answer in **(c)(i)** and the **second** step of the mechanism, explain why one chlorine atom is able to destroy thousands of ozone molecules. [2]

A6 A student carried out an experiment to investigate the speed of reaction between sodium thiosulfate solution and dilute hydrochloric acid.

$$Na_2S_2O_3\ (aq) + 2HCl\ (aq) \rightarrow 2NaCl\ (aq) + S\ (s) + H_2O\ (l) + SO_2\ (g)$$

In experiment 1, 50 cm^3 of sodium thiosulfate solution was poured into a 100 cm^3 beaker using a measuring cylinder. The beaker was placed on a cross drawn on a piece of paper. 10 cm^3 of dilute hydrochloric acid was added to the beaker and the stopwatch was started simultaneously.



The time taken for the cross to be completely covered will be recorded.

Experiment **1** was repeated using different volumes of sodium thiosulfate solution, diluted with different volumes of water as shown in the table below. All experiments were carried out at 25.0°C.

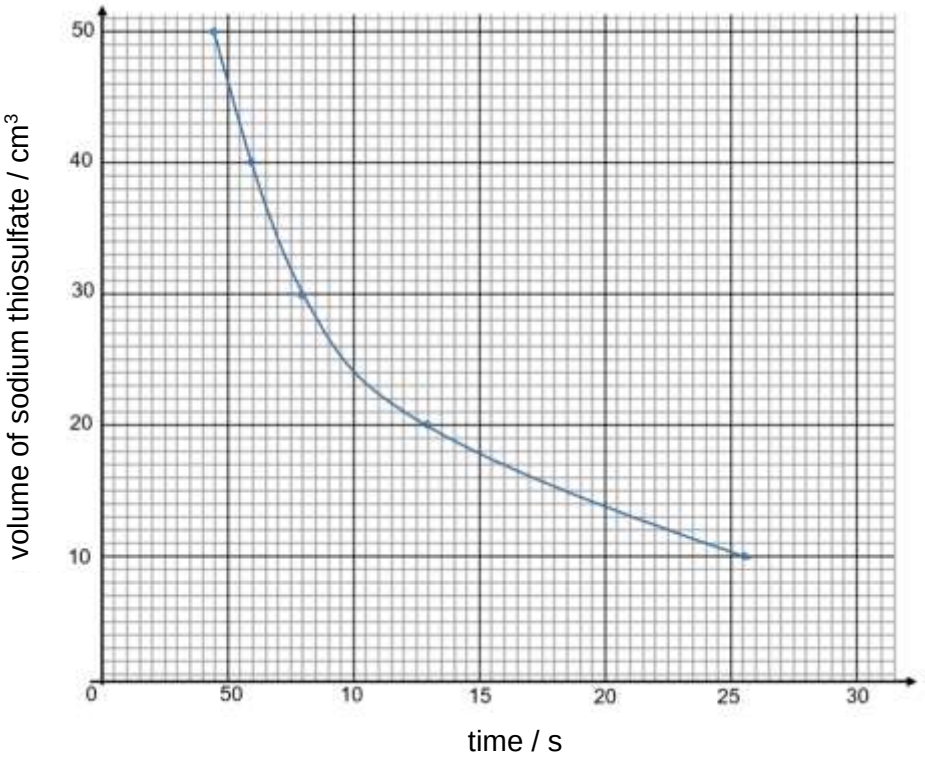
experiment	1	2	3	4	5
volume of sodium thiosulfate solution / cm^3	50	40	30	20	10
volume of water / cm^3	0	10	20	30	40

(a) Explain why the cross on the paper disappeared. [1]

(b) Write down the formula of the thiosulfate ion. [1]

(c) It was advised that good ventilation should be ensured when carrying out this experiment. Explain why this is so. [1]

(d) **(i)** The results of experiment **1** to **5** were plotted as shown in the graph. Sketch, on the same graph, showing the likely results of experiment **1** to **5** when it is repeated at 40.0°C. [1]



(ii) Using ideas about collisions between particles, explain why a higher temperature affects the rate of reaction. [2]

A7 Decomposition reactions occur when a reactant breaks down into two or more products. The two reactions below show the decomposition of ammonium compounds that are quite different. One is a non-redox reaction while the other is a redox reaction.

equation **1** : $NH_4Cl \rightleftharpoons NH_3 + HCl$

equation **2** : $NH_4NO_3 \rightarrow N_2O + 2H_2O$

(a) Explain, in terms of oxidation states, why equation **1** is a non-redox reaction. [1]

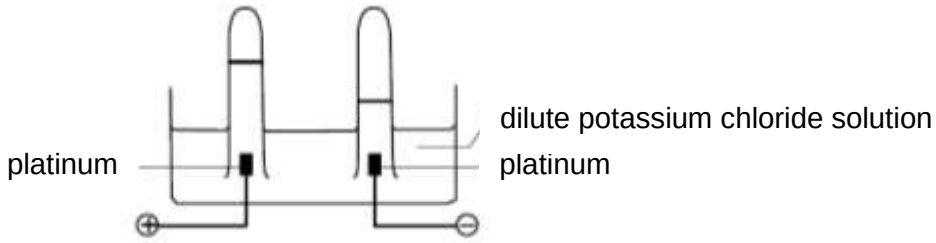
(b) Explain, in terms of oxidation states and with reference to one of the elements in ammonium nitrate, why equation **2** is a redox reaction. [2]

(c) Nitrogen is an element that can display multiple oxidation states. Sodium azide, NaN_3, exists as a white solid and is commonly found in the airbags in vehicles.

(i) State the oxidation state of nitrogen in an azide ion, N_3^-. [1]

(ii) Describe, in terms of arrangement and movement, of the particles present in sodium azide at room temperature and pressure. [2]

A8 The electrolysis of dilute aqueous potassium chloride with platinum electrodes is carried out in the setup below. The volumes of gases liberated at the electrodes is shown below.



(a) Write the ionic half equations, with state symbols, for the reactions occurring at each electrode. [2]

anode : _____

cathode : _____

(b) It was found that 8 cm^3 of gas is collected at the cathode after one minute under room conditions. Using your answer to **(a)**, determine the volume of gas collected in the anode after one minute. [1]

_____

(c) A few drops of methyl orange indicator were added to the electrolyte.
State the colour change observed near the cathode. [1]

_____

(d) The electrolysis is continued over a long period of time and a greenish-yellow gas is liberated at the anode. Explain this observation. [2]

_____

_____

_____

_____

Section B

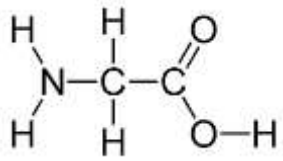
Answer all **three** questions from this section.
The last question is in the form of either/or and only **one** of the alternatives should be attempted.
The total marks for this section is **30**.

B9 In 1907, Leo Baekeland invented the first synthetic plastic known as Bakelite. The understanding of polymers had come a long way since then. Two common types of polymerization are addition polymerization and condensation polymerization. The chemical and physical properties of polymers vary significantly from their respective monomers. Polymers are an essential part of life and many forms of polymers can be found around us.

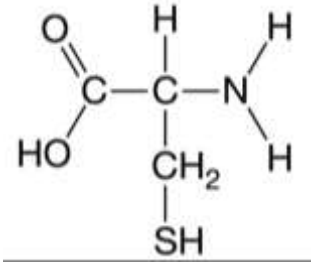
Condensation Polymerisation

Amino acids are compounds that contain the amino ($-NH_2$) group and carboxyl (-COOH) group. Amino acids are the monomers prior to the formation of protein via condensation polymerization. The human body requires 20 different amino acids to function properly. The displayed formula of three of the essential amino acids are shown below.

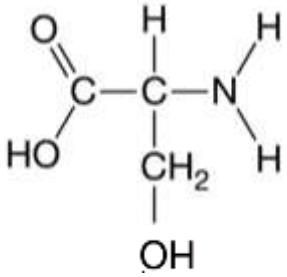
glycine



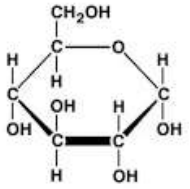
cysteine



serine

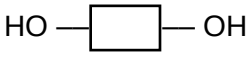


Polysaccharides, also known as polycarbohydrates, are the most common carbohydrate found in food. Polysaccharides are great source of energy that the human body can utilize and break down when needed. An example of such a polysaccharide is starch which is formed from the glucose, $C_6H_{12}O_6$, monomer via a condensation polymerization with the formation of water molecules.



glucose

The structure of glucose can be represented as the diagram shown below.



(a) Explain two differences between addition polymerization and condensation polymerization. [2]

(b) Poly(propene) is an addition polymer. Draw the structure of polypropene, showing 3 repeat units. [1]

(c) Name another functional group present in serine other than amino and carboxyl functional groups. [1]

(d) A protein is made from serine and glycine monomers. Draw the structure of the protein, showing 2 repeat units. [1]

(e) The thionyl group, -SH, in cysteine is a weakly acidic functional group, similar to the carboxylic acid functional group. Draw the structure of the organic product when cysteine is reacted with sodium hydroxide. [1]

(f) Describe, with the relevant observations, a simple chemical test to distinguish between cysteine and serine. [2]

(g) Serine, an alcohol, can be manufactured from $C_3H_5O_2N$, an alkene. State the reagents and conditions needed for this reaction. [1]

(h) Draw the structure of starch, showing 3 repeat units. [1]

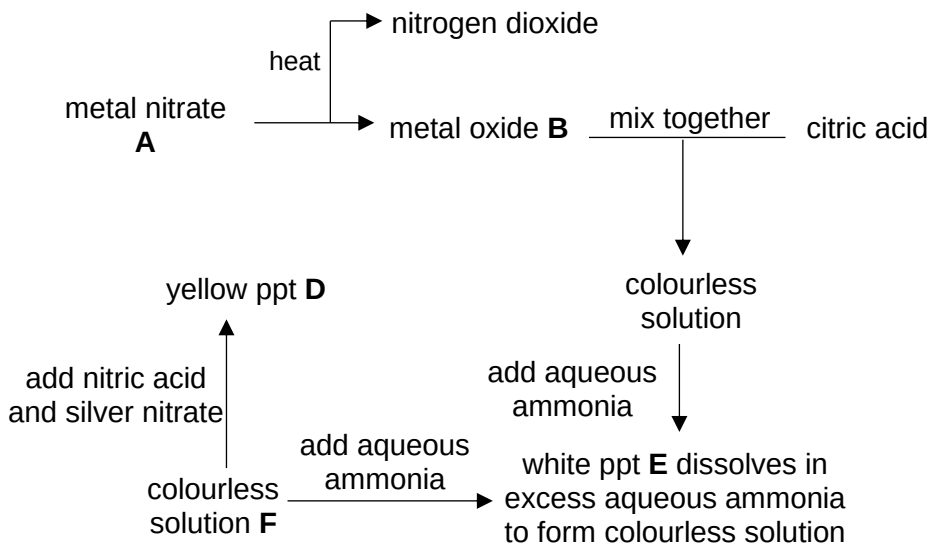
B10 Eno fruit salt is an over-the-counter antacid brand that is commonly used to help ease digestion and they can come in different flavours. The main ingredients are sodium carbonate, anhydrous sodium hydrogencarbonate and citric acid.

(a) One common trait among the different brands of eno fruit salts is that effervescence is observed when water is added.

(i) Explain why effervescence is observed when water is added to the eno fruit salt solids. [2]

(ii) Describe a chemical test, along with the expected observations, to test for the identity of the gas liberated. [2]

(b) The flowchart below shows the reactions involving citric acid.



(i) Name the substances **A**, **D** and **E**. [3]

A : _____

D : _____

E : _____

(ii) Write a balanced ionic equation, with state symbols, for the formation of the white precipitate **E**. [1]

_____

(iii) Calcium citrate is an insoluble compound. Describe how a pure and dry sample of calcium citrate can be formed from sodium citrate solution. [2]

_____

_____

_____

_____

Either

B11 Carbon chemistry in the areas of diamond and graphite has an interesting similarity to boron-nitrogen chemistry in the area of boron nitride. Boron nitride can exist in a hexagonal form, similar to graphite. The layers of hexagonal rings in boron nitride consists of boron-nitrogen single covalent bond.

(a) State a physical property expected of boron nitride other than the electrical conductivity. [1]

(b) State and explain, in terms of bonding and structure, whether boron nitride has a high or low melting point. [2]

(c) Graphite can be reacted to form diamond under the appropriate pressure and temperature.

$$C\ (graphite) \rightarrow C\ (diamond) \qquad \Delta H = +\ 1.7\ kJ/mol$$

(i) Calculate the energy absorbed when 120 g of graphite reacts to produce diamond. [2]

(ii) Sketch the energy profile diagram for the formation of diamond from graphite, showing the enthalpy change and the activation energy. [3]

(d) Even though graphite and boron nitride have many similarities, boron nitride is unable to conduct electricity. It is suggested that boron nitride can be made an electrical conductor by inserting an alkali metal into its structure. A scientist also discovered that the taste of the solution of the alkali metal halides (chlorides/bromides/iodides) depends on the sum of the ionic radii of the ions. The taste of the respective alkali metal halides can be inferred from the data below:

ion	ionic radius / nm	ion	ionic radius / nm
Na^+	0.098	Cl^-	0.181
K^+	0.133	Br^-	0.196
Rb^+	0.148	I^-	0.219
Cs^+	0.167		

alkali metal halide	sum of ionic radii / nm	taste
sodium iodide	0.319	salty
potassium chloride		salty
rubidium chloride		salty and bitter
caesium chloride		bitter
rubidium bromide	0.344	bitter

(i) Fill in the table above the respective values for the sum of ionic radii. [1]

(ii) Based on your answer in **(d)(i)**, predict the taste of potassium bromide. [1]

OR

B11 Cathodic protection is a simple method of protection which connects the metal to be protected to a "sacrificial metal". Diagram **A** shows a layer of zinc coating that has been damaged, exposing a small area of the iron it was meant to protect.

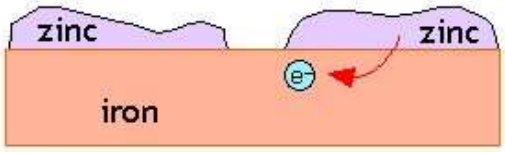


diagram **A**

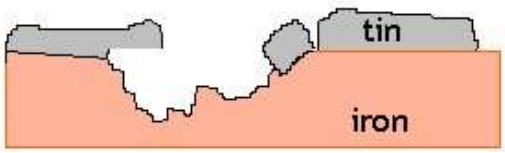


diagram **B**

(a) State the name of the process by which a thin layer of zinc is coated onto iron to protect iron from corroding. [1]

(b) In diagram **A**, although a portion of the zinc layer is damaged, the iron is seen to remain intact and does not appear to corrode over time. Explain clearly how zinc prevents the iron from corroding. [3]

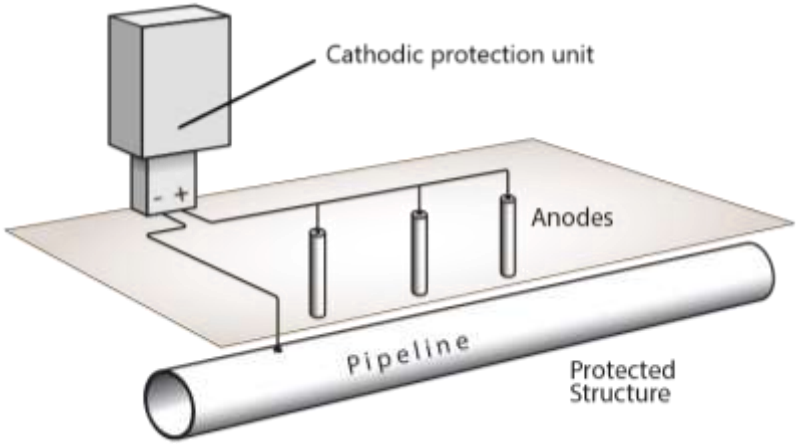
(c) State the identity of the cathode in diagram **B** [1]

(d) Diagram **B** shows how tin is used to protect iron in commonly found tin-plated canned food. However, any damage to the tin coating actively causes the rapid corrosion of the iron beneath it in the presence of oxygen and water, as seen in diagram **B**. Explain why this happens. [2]

(e) The formation of rust can be represented in the equation below. Balance the equation. [1]

_____ Fe (s) + _____ O_2 (g) + _____ xH_2O (l) → _____$Fe_2O_3.xH_2O$

(f) A more sophisticated type of cathodic protection is to use an external direct current power supply provided by a cathodic protection unit, commonly used to protect oil pipelines and other buried structures from corrosion, as shown below.



(i) Show the direction of the electron flow by drawing arrows in the diagram. [1]

(ii) Explain why the anodes need not function as a "sacrificial metal" anymore. [1]

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.).