Name: ______________________________ (   )   Class: _____

CHIJ KATONG CONVENT
PRELIMINARY EXAMINATIONS 2020
Secondary Four Express

CHEMISTRY — 6092/02

Duration: 1 hour 45 minutes

Class: 405, 406

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your name, registration 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 staples, paper clips, highlighters, glue or correction fluid/ tape.

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.

You are advised to spend no longer than one hour on Section A and no longer than 45 minutes on Section B.

At the end of the examination fasten all your work securely together.
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 24.

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

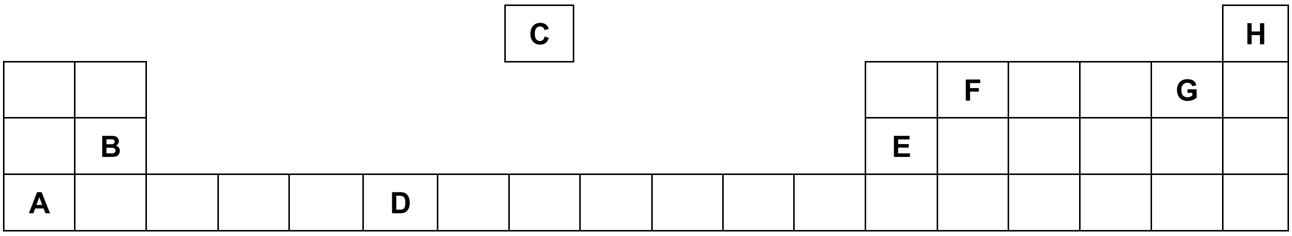
FOR EXAMINER'S USE	
Paper 1	/ 40
Section A	/ 50
Section B	/ 30
TOTAL	/ 120

This question paper consists of **24** printed pages.

Section A

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

A1 The position of eight elements, **A**, **B**, **C**, **D**, **E**, **F**, **G** and **H** are shown in the outline of part of the Periodic Table.



Use the letters **A**, **B**, **C**, **D**, **E**, **F**, **G** and **H** to answer the following questions. You may use the letter once, more than once, or not at all.

(a) Which element has atoms with no neutrons?

……… [1]

(b) Which element(s) form(s) ions with +1 charge?

……… [1]

(c) Which element has similar chemical properties to barium?

……… [1]

(d) Which element forms an oxide that reacts with both an acid and a base?

……… [1]

(e) Which element forms coloured compounds?

……… [1]

(f) Which element is the strongest oxidising agent?

……… [1]

[Total: 6]

A2 Chlorine exists as two isotopes – chlorine-35 and chlorine-37.

(a) State the number of electrons, neutrons and protons in an ion of chlorine-37.

…………………. electrons

…………………. neutrons

………………….. protons [1]

(b) In a sample of 100 chlorine atoms, there are 76 atoms of chlorine-35 and 24 atoms of chlorine-37.

Find the average relative atomic mass of this chlorine sample.

average relative atomic mass = ………………………… [2]

(c) An element X is found in period 2 of the Periodic Table. It reacts with chlorine to form a chloride with the formula XCl_3, which has a melting point of –50 °C and a boiling point of 15 °C.

(i) State and explain the type of structure that exists in XCl_3.

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

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

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

…………………………………………………………………………………………………… [2]

(ii) Draw a 'dot-and-cross' diagram to show the arrangement of outer shell electrons in XCl_3.

[2]

[Total: 7]

A3 In order to investigate the properties of two dilute monobasic acids, prussic acid (HCN) and nitric acid, two tests were carried out and the results are as recorded in the table. Equal concentrations of acids were used in each test.

test	procedure	results and observations	
		prussic acid	nitric acid
1	Add 3.00 g of sodium carbonate to 20 cm^3 of the acid. Measure time taken to collect 20 cm^3 of gas.	effervescence of colourless gas 67 s to collect 20 cm^3 of gas	effervescence of colourless gas 24 s to collect 20 cm^3 of gas
2	Add 2 magnesium strips to 20 cm^3 of the acid. Measure the total volume of gas **Y** evolved.	effervescence of colourless gas 43 cm^3 of gas **Y** collected	effervescence of colourless gas 43 cm^3 of gas **Y** collected

(a) **(i)** Identify gas **Y**.

.... [1]

(ii) Give the formula of the salt which forms with prussic acid in test 1.

.... [1]

(b) **(i)** Is prussic acid a strong or weak acid?

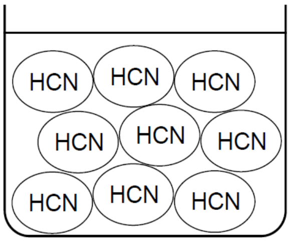
Explain your answer using information from the table.

....

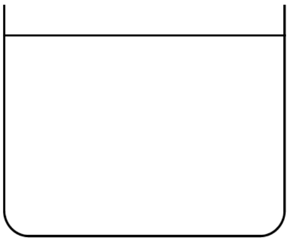
.... [1]

(ii) A diagram of liquid hydrogen cyanide is shown below.

Draw a labelled diagram showing the arrangement of particles in a solution of prussic acid.



liquid hydrogen cyanide


solution of prussic acid

[1]

[Total: 4]

A4 Octane, C_8H_{18}, is a main component present in motorcar fuel. When burned in excess oxygen, carbon dioxide and water are produced. The enthalpy change for the burning of octane is –5500 kJ/ mol.

(a) Explain, in terms of bond making and bond breaking, why the enthalpy change has a negative sign, when 1 mole of octane is completely burned.

....

....

....

....

....

.... [3]

(b) Draw an energy profile diagram for the combustion of octane.

Your diagram should include:

- the formulae of the reactants and products,
- labels to show the enthalpy change of reaction and the activation energy.

[3]

[Total: 6]

A5 Susan reacted some potassium hydroxide with phosphoric acid.

$$3KOH(aq) + H_3PO_4(aq) \rightarrow K_3PO_4(aq) + 3H_2O(l)$$

(a) At the end of the reaction, 46.3 g of K_3PO_4 is produced and 92.8 g of H_3PO_4 remains unreacted.

(i) Calculate the starting mass of KOH.

[2]

(ii) Calculate the starting mass of H_3PO_4.

[2]

(b) Susan suggested using potassium instead of potassium hydroxide for this experiment in the school laboratory.

Suggest a reason why you will not recommend Susan to conduct this experiment.

………

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

(c) Potassium oxide reacts in a similar manner to potassium hydroxide.

Susan wants to obtain potassium from potassium oxide. She decides to heat potassium oxide with carbon.

Is this method feasible?

Explain your reasoning.

………

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

A5 (d) Describe how Susan can prepare a pure, dry sample of K_3PO_4 crystals after obtaining the resulting mixture using stoichiometric masses of KOH and H_3PO_4.

………

………

………

………

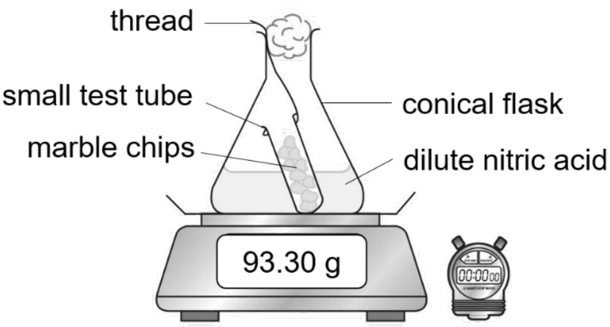
………

…………………………………………………………………………………………………… [3]

[Total: 9]

A6 A student investigated the reaction between marble chips, $CaCO_3$, and dilute nitric acid, HNO_3.

The diagram shows the apparatus used by the student.



The student pulled the thread to add the marble chips to dilute nitric acid. She recorded the reading on the electronic balance every minute and the table shows the results.

time/ min	balance reading/ g
0	93.30
1	93.28
2	93.26
3	93.24
4	93.22
5	93.21
6	93.20
7	93.19
8	93.18
9	93.17
10	93.16
11	93.15
12	93.15
13	93.14
14	93.14

(a) Describe and explain the trend in balance reading obtained by the student.

……………………………………………………………………………………………………

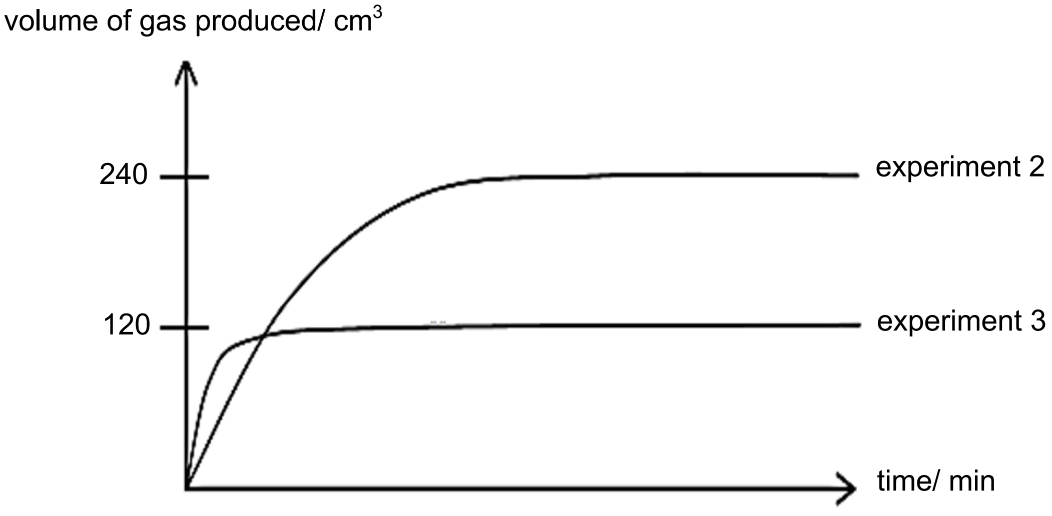
……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

A6 (b) The student repeated the same experiment twice under different conditions and named them experiment 2 and experiment 3. Both experiments were conducted at room temperature and pressure, with excess lumps of marble chips. The speed of reaction was determined by measuring the volume of gas produced at regular time intervals.

The results of experiments 2 and 3 are shown on the graph.



(i) 50 cm^3 of 2.00 mol/dm^3 nitric acid was used in experiment 2.

Suggest the concentration and volume of nitric acid used in experiment 3

concentration ……………………………

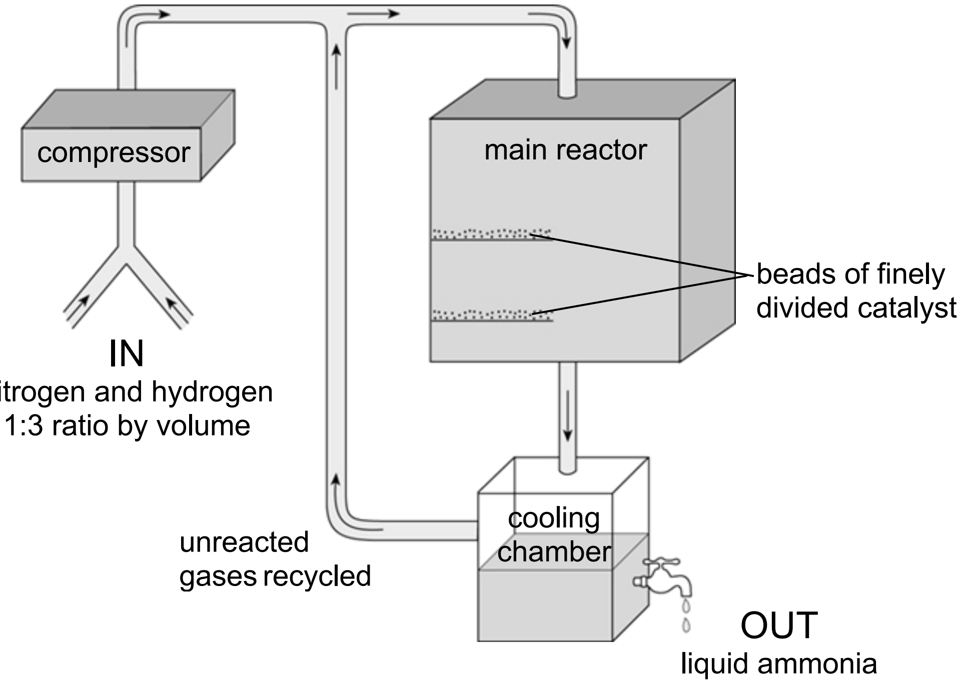
volume …………………………………… [2]

(ii) Experiment 4 was carried out using 50 cm^3 of 2.00 mol/dm^3 nitric acid at 50˚C with excess lumps of marble chips.

Sketch a curve on the graph to show the pattern of results for experiment 4. [1]

[Total: 5]

A7 The diagram shows the Haber process for making ammonia.



(a) Explain, with the help of an equation, why nitrogen and hydrogen are mixed in a 1:3 ratio by volume.

………

………

………

……… [2]

(b) When the mixture of hydrogen, nitrogen and ammonia gases enters the cooling chamber, ammonia turns to a liquid but the other gases do not.

What does this information suggest about the physical properties of the three gases?

………

……… [1]

(c) Other than cost, suggest why unreacted hydrogen is recycled.

………

……… [1]

A7 (d) Ammonia is used to manufacture nitric acid by a two-stage process.

Stage 1: Ammonia is converted to nitrogen monoxide.
$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(l)$

Stage 2: Nitrogen monoxide is converted to nitric acid.
$4NO(g) + 2H_2O(g) + 3O_2(g) \rightarrow 4HNO_3(aq)$

(i) It is possible to find out whether stage 1 has finished by following pH changes during the reaction. Samples of gas are taken from the reaction vessel at intervals and bubbled through water to form a solution. The pH of each solution is measured.

Explain why the measured pH changes during the reaction in stage 1.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(ii) Calculate the maximum volume of 5 mol / dm^3 nitric acid which can be made from 720 dm^3 of nitrogen monoxide at room temperature and pressure.

[2]

(iii) Write an overall equation for the conversion of ammonia to nitric acid.

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

[Total: 9]

A8 The head of a safety match contains potassium chlorate(V) and antimony(III) sulfide. The side of the matchbox contains red phosphorus.

When a match head is struck on the side of the box, the friction produces enough heat to light the match. The equation for this reaction is shown.

$$5KClO_3 + 6P \rightarrow 5KCl + 3P_2O_5$$

(a) What is meant by '(V)' in potassium chlorate(V)?

.... [1]

(b) Potassium chlorate(V) is the oxidising agent in this reaction.

Explain, in terms of oxidation state, the validity of this statement.

....

....

.... [2]

(c) The cation in antimony(III) sulfide found in the match head can be reduced to its metal by a reducing agent.

Write an ionic equation to show the transfer of electrons involved in this reduction reaction.

.... [1]

[Total: 4]

Name: ______________________________ ( ) Class: __________

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.

B9 What is hard water?

Hard water contains calcium ions. It is the result of the reaction between rainwater (containing dissolved carbon dioxide) and limestone (mainly calcium carbonate) to form calcium hydrogen carbonate.

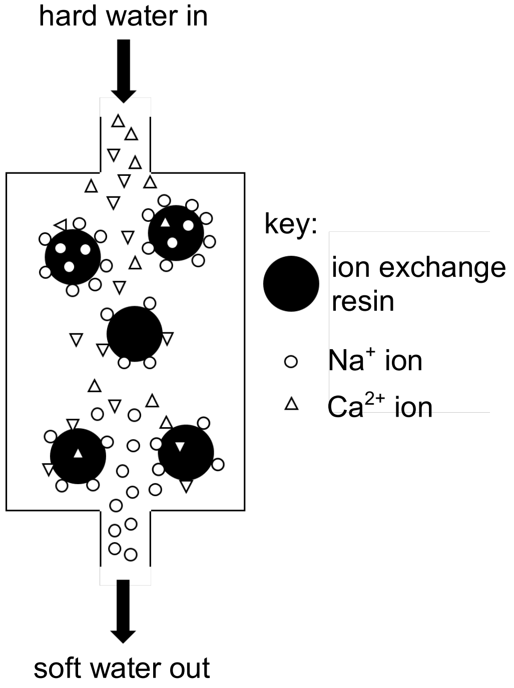
$$CaCO_3(s) + CO_2(aq) + H_2O(l) \rightarrow Ca(HCO_3)_2(aq)$$

Hard water and soap

Most typical soaps contain sodium stearate, $C_{17}H_{35}COONa$. Soap only works when stearate ions are in aqueous solution. Calcium ions present in hard water removes the stearate ions in a precipitation reaction, forming calcium stearate which is commonly known as white scum. A white mass of bubbles, or lather, will not be formed until all the calcium ions in hard water have reacted with stearate ions to form scum. In hard water areas, this involves wasting a lot of soap as well as the unpleasantness of washing in water with a thick layer of scum on it.

Problems caused by limescale formed by hard water

Besides the formation of scum, hard water also forms limescale (calcium carbonate) when it is heated. Limescale can block water pipes, leading to a waste of energy. In electric kettles, limescale coating on the iron heating element slows the transfer of heat to the water. Limescale can be removed by using descalers or vinegar (dilute ethanoic acid).



Removing ions that cause hard water

Hard water can be softened by adding washing soda containing sodium carbonate. The resulting mixture is then filtered to obtain soft water.

Domestic water softeners consist of small beads of ion exchange resin packed into a container. Hard water flows through this and exits from the other end as soft water.

The ion exchange resin exchanges other positive ions for sodium ions. The resin is a complex lattice with sodium ions attached to it. Calcium ions in hard water attach to the lattice and the sodium ions are washed off.

Some ion exchange resins replace both positive and negative ions with hydrogen and hydroxide ions. The water emerging from such resins is known as deionised water.

B9 Testing of hardness of water

The hardness of water can be tested using a titration set-up. Soap solution in a burette is added dropwise to a fixed volume of water sample in a conical flask. The water sample is shaken vigorously after each addition to check for the formation of lather. The volume of soap solution needed to form lather is then recorded.

(a) Deduce the formula for calcium stearate.

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

(b) When carbon dioxide gas is bubbled into limewater, a white precipitate forms. On further bubbling, the white precipitate dissolves in limewater to form a colourless solution.

(i) Explain what happened when more carbon dioxide is bubbled into limewater.

…………………………………………………………………………………………………

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

(ii) Suggest what could be done to obtain the white precipitate again from the colourless solution.

…………………………………………………………………………………………………

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

(c) Limescale can form on the iron heating element in an electric kettle after using it to boil hard water.

(i) Describe and explain how the formation of limescale on the heating element in electric kettles will affect the time taken to boil water.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(ii) Is it advisable to use hydrochloric acid instead of vinegar to remove limescale on heating elements?

Explain your reasoning.

…………………………………………………………………………………………………

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

B9 **(d)** Describe a simple chemical test to confirm the absence of hard water in the water collected from the domestic water softener.

………

………

………

……… [2]

(e) The table shows the volume of soap solution needed to form lather for two different water samples of the same volume.

water	**volume of soap solution/ cm^3**
sample 1	1.7
sample 2	4.3

Explain, in terms of ions present, which sample contains water with higher hardness.

………

………

………

……… [2]

[Total: 10]

B10 **(a)** Aluminium is extracted by electrolysis from its ore, bauxite which contains aluminium oxide. Cryolite (Na_3AlF_6) is then added to molten bauxite to attain an optimum temperature of about 1000 ºC. The melting point of bauxite is about 2045 ºC.

Blocks of carbon act as the anodes while the carbon lining the cell acts as the cathode. The anodes, however require regular replacement as they get corroded with use. The electrolytic cell used is shown in Fig. 10.1.

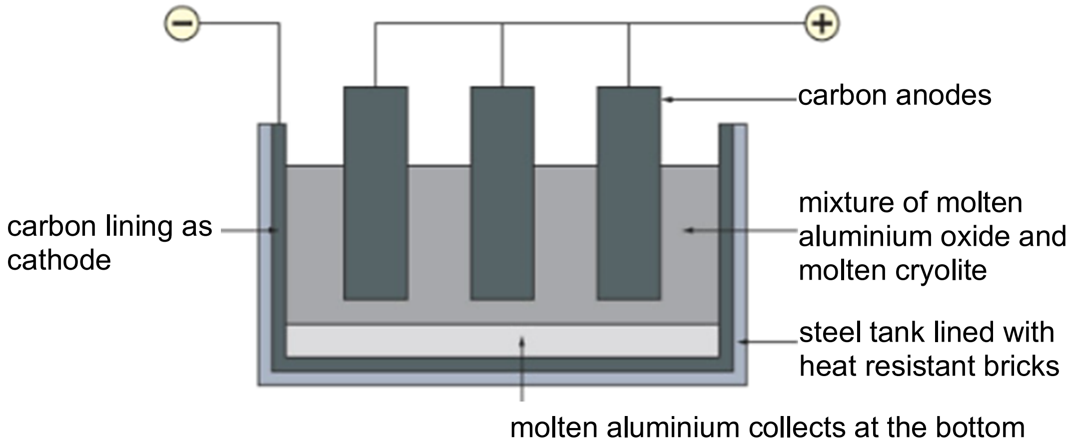


Fig. 10.1

(i) Write balanced half-equations for the reactions occurring at the anode and cathode.

anode: ……………………………………………………………………………………………

cathode: ………………………………………………………………………………………… [2]

(ii) Describe how the carbon anodes are corroded.

……………………………………………………………………………………………………

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

(iii) Explain how the addition of cryolite lowers the melting point of molten bauxite.

……………………………………………………………………………………………………

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

(iv) Suggest a reason why industries add cryolite to obtain a lower operating temperature.

……………………………………………………………………………………………………

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

B10 (b) Although aluminium is a reactive metal, it has the ability to resist corrosion. The thin oxide layer, which forms on the surface, protects the metal from air and water. This corrosion resistant ability can be further enhanced by making the oxide layer thicker. This technique is known as anodising.

The first step in anodising is to remove the existing layer of aluminium oxide. This is done by dipping the aluminium into sodium hydroxide solution. The alkali reacts with the aluminium oxide on the surface, exposing the underlying aluminium metal. The 'bare' aluminium is then used as the anode in the electrolysis of dilute sulfuric acid. The cathode material used is usually a metal, such as lead. Fig. 10.2 shows the set-up after electrolysis has run for some time.

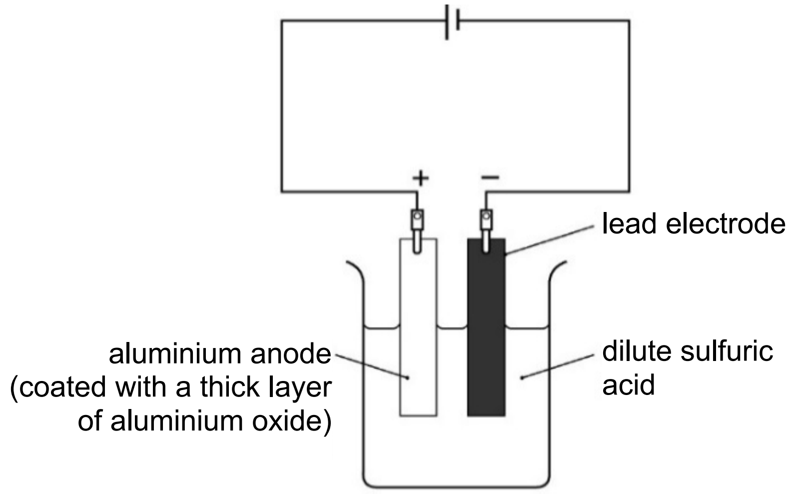


Fig. 10.2

(i) Explain how the oxide layer at the anode becomes thicker.

Your answer should include a suitable equation, which supports the explanation.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(ii) Suggest why sodium hydroxide can be used to remove the layer of aluminium oxide before anodising.

……………………………………………………………………………………………………

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

(iii) Give one observation seen at the cathode during anodising.

……………………………………………………………………………………………………

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

B10 (b) (iv) The lead cathode is periodically taken out for cleaning and inserted again in the electrolyte, dilute sulfuric acid, to ensure the efficiency of the anodising process.

Suggest a reason for this.

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

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

[Total: 10]

EITHER

B11 Fig. 11.1 shows the types of fuel used in 1990 and 2002**.**

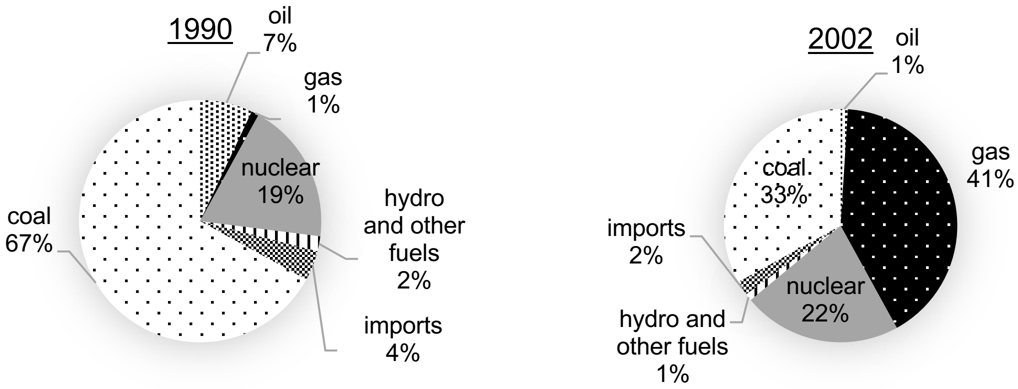


Fig. 11.1

Fig. 11.2 shows the relationship between the air : fuel ratio and the production of pollutants in vehicle engines.

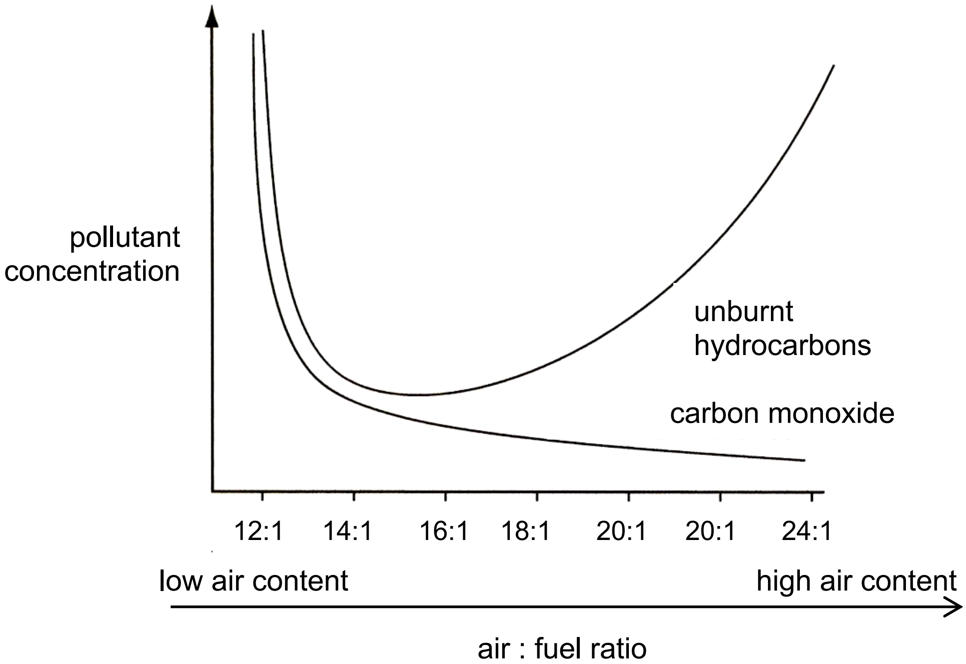


Fig. 11.2

(a) Use the information in Fig. 11.1 to describe the changes in the main type of fuel used from 1990 to 2002.

………

………

………

……… [2]

B11 **(b)** Describe and explain the trend for carbon monoxide production in Fig. 11.2.

………

………

………

……… [2]

(c) Apart from carbon monoxide and unburnt hydrocarbons, oxides of nitrogen are also air pollutants produced by vehicle engines.

(i) Explain how oxides of nitrogen are formed in vehicle engines.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(ii) Predict the air : fuel ratio where the concentration of oxides of nitrogen is the highest. Explain your answer.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [3]

(d) It was observed that crops do not grow well in areas near coal-burning power stations.

Suggest an explanation for this observation.

………

……… [1]

[Total: 10]

OR

B11 Iron rusts in the presence of oxygen and water. Rusting involves a series of reactions. One of the components found in rust is hydrated iron(III) hydroxide.

Fig. 11.1 shows the reactions that go on in one part of a piece of iron when it rusts.

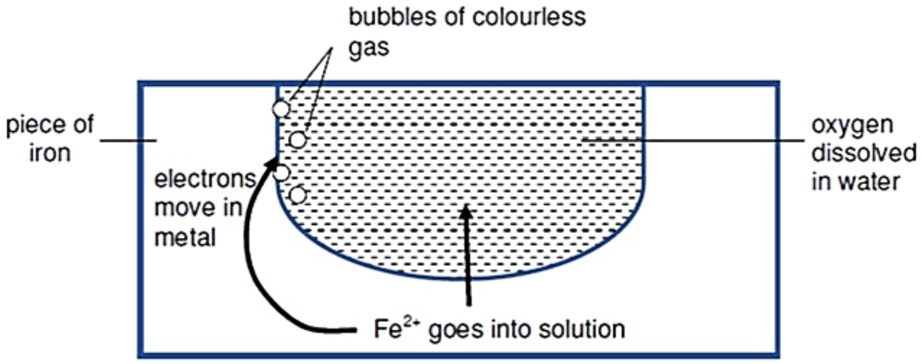


Fig. 11.1

Initially iron atoms lose electrons to form iron(II) ions.

$$Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$$

At the same time oxygen and water molecules react to form hydroxide ions.

$$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$$

Aqueous iron(II) ions then react with aqueous hydroxide ions to form solid iron(II) hydroxide.

(a) Using the equations given, write the overall chemical equation, including state symbols, for the formation of iron(II) hydroxide.

………………………………………………………………………………………………… [2]

(b) The iron(II) hydroxide formed then reacts with more oxygen and water to form iron(III) hydroxide.

Write the equation for the formation of iron(III) hydroxide in this process.

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

B11 (c) A method of preventing rusting of underground steel pipes is sacrificial protection. A block of magnesium is connected by a piece of copper wire to a steel pipe as shown in Fig. 11.2.

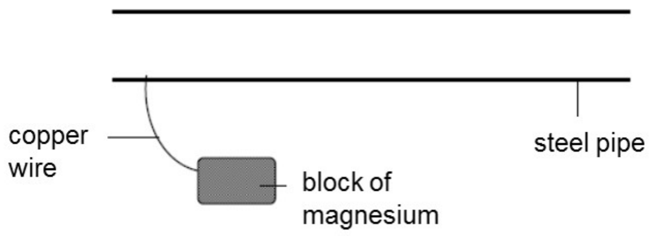


Fig. 11.2

The steel in electrical contact with magnesium does not rust.

Explain why.

………

………

………

……… [2]

(d) Another method of preventing the rusting of steel is cathodic protection. A set-up showing cathodic protection is shown in Fig. 11.3.

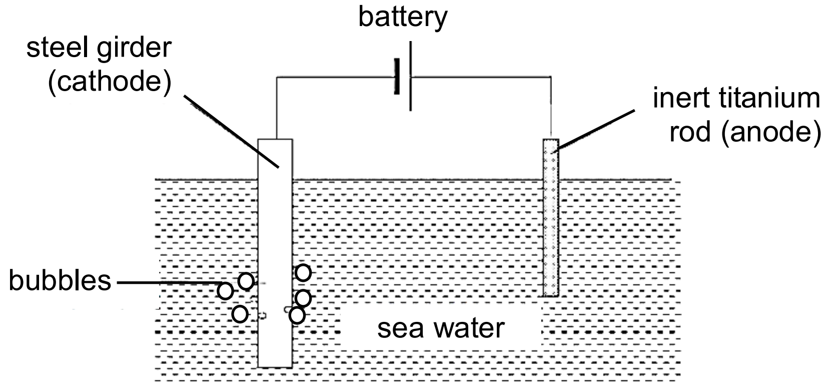


Fig. 11.3

B11 (d) (i) Bubbles are given off at the steel cathode.

Explain the observation.

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

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

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

……………………………………………………………………………………………… [2]

(ii) Give two differences between sacrificial and cathodic protection in the prevention of rusting of steel.

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

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

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

……………………………………………………………………………………………… [2]

(iii) Suggest one advantage of cathodic protection over sacrificial protection.

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

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

[Total: 10]

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 A*l* aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 C*l* 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 T*l* 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 F*l* 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.).