Name: _____ ( ) Class: _____

WHITLEY SECONDARY SCHOOL

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PRELIMINARY EXAMINATION 2024

SUBJECT	**:**	**Chemistry (6092/02)**
LEVEL	**:**	**Secondary 4 Express**
DATE	**:**	**20 August 2024**
DURATION	**:**	**1 hour 45 minutes**
SETTER	**:**	**Mrs Ambikai**
VETTERS	**:**	**Ms Charlene Lye and Mr Ng Mun Leong**

READ THESE INSTRUCTIONS FIRST
Write your name, class and index number in the spaces at the top of this page.
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.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers 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		
Section **A**		**/70**
Section **B**		**/10**
Total		**/80**

This paper consists of **20** printed pages.

Section A

Answer **all** questions.

1 Table 1.1 below shows a list of elements and their atomic and mass numbers.

Table 1.1

element	A	B	C	D	E	F	G	H
atomic Number	8	12	16	17	18	28	31	35
mass Number	16	24	32	37	40	59	70	80

Using only the elements from Table 1.1, choose an element which matches the following descriptions. Each element can only be used once.

(a) Forms coloured compounds.

……..……..... [1]

(b) Forms an oxide that reacts with acids only.

……...……...……...……... [1]

(c) Forms an anion with a charge of -2 most readily.

……..……. [1]

(d) Could be an isotope of chlorine-35.

…….. [1]

(e) A gas used to fill up light bulbs.

…….. [1]

[Total: 5]

2 Fig. 2.1 describes reactions involving a pale green solid, **A**.

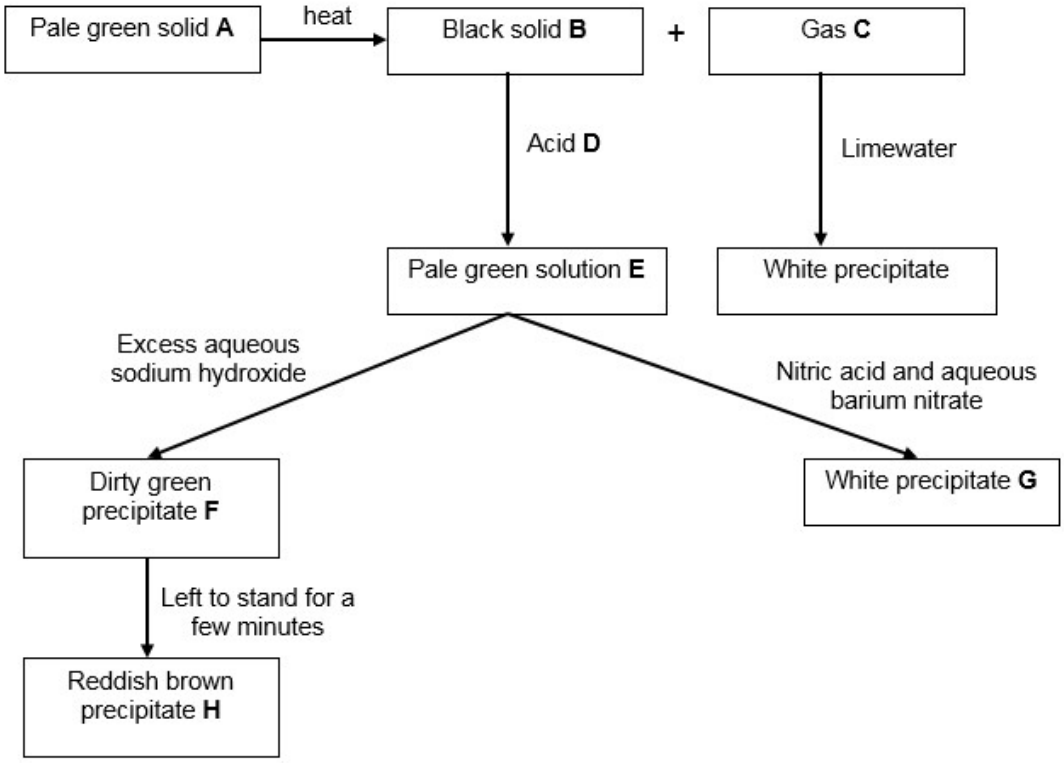


Fig. 2.1

(a) Name **A**, **B**, **C** and **D**.

A .....

B .....

C .....

D ..... [4]

(b) Write the ionic equation for the reaction between **B** and acid **D**.

..... [1]

(c) Explain why precipitate **F** changed to form reddish brown precipitate **H** when left to stand for a few minutes.

.....

..... [1]

[Total: 6]

3 The diagram in Fig. 3.1 shows the formation of boron trifluoride. Only valence electrons are shown in the diagram.

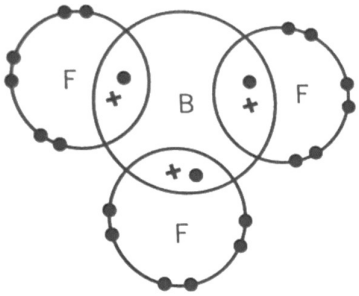


Fig. 3.1

(a) Using the information from the above diagram, explain if you would classify boron as a metal or non-metal.

……

……

…….. [1]

(b) State what is unusual about the bonding in boron trifluoride.

……

……

……

…….. [2]

(c) Using your knowledge of chemical bonding, predict whether the melting point of boron trifluoride will be generally high or low. Explain your answer.

……

……

……

…….. [2]

[Total: 5]

4 Vanadium and manganese are metals which can form variable oxidation states and compounds of different colours.

(a) Table 4.1 shows the colours of vanadium in different oxidation states. Complete the oxidation states of vanadium in the table.

Table 4.1

substance	colour	oxidation state of Vanadium
$[V(H_2O)_6]^{3+}$	green	
$[VO_2]^{+}$	yellow	
$[V(H_2O)_6]^{2+}$	violet	
$[VO]^{2+}$	blue	

[2]

(b) Manganese nitrate, $Mn(NO_3)_2$, decomposes upon strong heating to form manganese oxide, MnO_2, and nitrogen dioxide gas.

(i) Write a balanced chemical equation for the decomposition of manganese nitrate.

..... [1]

(ii) Is the decomposition of manganese nitrate a redox reaction? Explain your answer using oxidation states.

.....

.....

.....

.....

.....

..... [3]

[Total: 6]

5 The graph in Fig. 5.1 shows the relative concentrations of oxides of nitrogen and carbon monoxide discharged from the exhaust system of a car against the air : fuel ratio in a moving car.

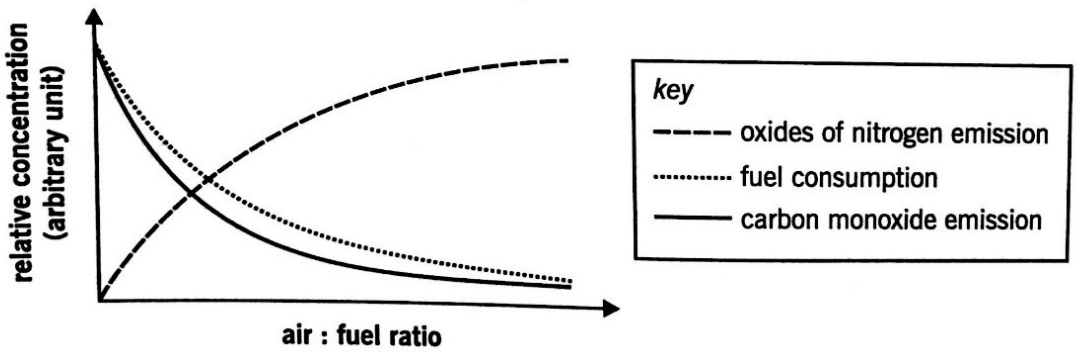


Fig. 5.1

(a) State the relationship between air : fuel ratio and relative carbon monoxide concentration emitted by the car. Explain your answer.

.....

.....

.....

.....

..... [3]

(b) Why does the concentration of oxides of nitrogen increase when air : fuel ratio increases?

.....

.....

.....

.....

..... [3]

(c) Catalytic converters are used in cars to remove pollutants like carbon monoxide and oxides of nitrogen. The use of catalytic converters increases the amount of carbon dioxide in the atmosphere.

Describe how carbon dioxide contributes to environmental problems. Give **two** specific examples of the problems caused.

……

……

……

……

…….. [4]

[Total: 10]

6 Air contains a mixture of gases including the noble gases neon, argon, krypton and xenon. These noble gases are monoatomic elements.

(a) State what is meant by monoatomic.

……

…….. [1]

(b) State why noble gases are unreactive.

……

…….. [1]

(c) State why fractional distillation can be used to separate a liquid mixture of neon, argon, krypton and xenon.

……

…….. [1]

(d) State and explain which noble gas has the fastest rate of diffusion at 20 ^{O}C.

……

……

…….. [2]

[Total: 5]

7 Chromium, iron and manganese are separately added to solutions of chromium (III) nitrate, iron (II) nitrate and manganese (II) nitrate. The colours of the solutions are recorded in Table 7.1.

Table 7.1

metal	salt solution		
	chromium (III) nitrate	iron (II) nitrate	manganese (II) nitrate
chromium		green solution turns purple	solution remains pink
iron	solution remains purple		solution remains pink
manganese	purple solution turns pink	green solution turns pink	

(a) Using the results, place the metals in decreasing order of reactivity. Explain your answer.

……

……

……

……

……. [3]

(b) Write an ionic equation for the reaction between manganese and iron (II) nitrate solution. Include state symbols.

……. [2]

(c) Chromium metal is added to another solution of copper (II) sulfate solution. Describe two observations.

……

……

……

……. [2]

[Total: 7]

8 Cyclopropene is an organic hydrocarbon with the structural formula as shown in diagram Fig. 8.1 below. Although not often used directly, some of its derivatives are used in the ripening of fruits.

Cyclopropene also reacts with chlorine gas to form 1,2-dichloropropane as shown in Fig. 8.2.

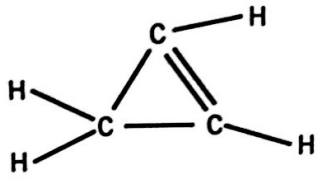


Fig. 8.1

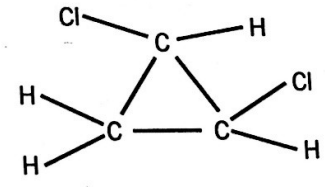


Fig. 8.2

(a) Write a balanced chemical equation to show the reaction between cyclopropene and chlorine.

..... [1]

(b) The table below shows some bond energies measured in kJ/mol.

bond	bond energy (kJ/mol)
C – C	348
C – H	413
C = C	614
C – Cl	330
Cl – Cl	243

Calculate the enthalpy change, ΔH, of the reaction between cyclopropene and chlorine.

[3]

(c) Draw a labelled energy profile diagram for this reaction.

[2]

[Total: 6]

9 Fig. 9.1 shows three electrolytic cells.

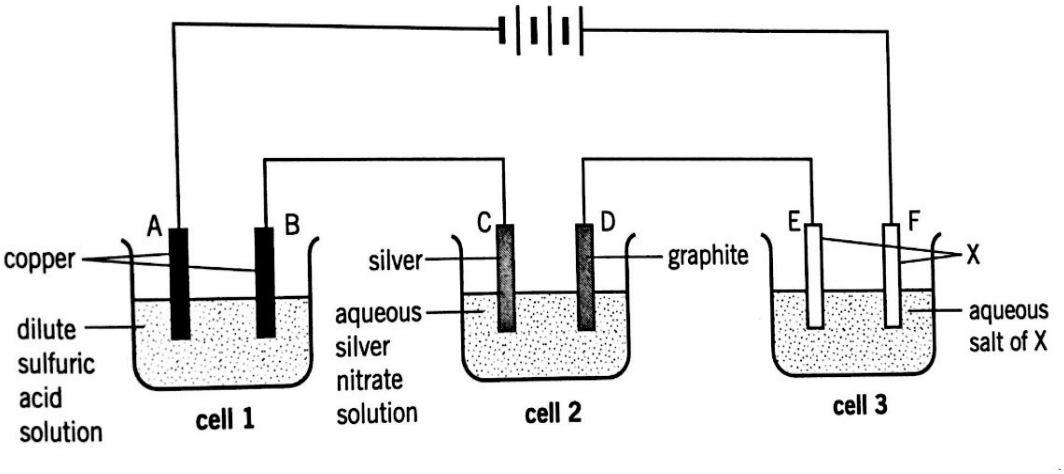


Fig. 9.1

Cell 3 uses an unknown metal **X** as the electrodes and an electrolyte containing metal **X** ions. Metal **X** has a relative atomic mass of 52.

(a) Identify the electrodes where the following observations will be made

(i) a layer of copper metal deposited.

……. [1]

(ii) bubbles of gas liberated.

……. [1]

(b) Write the half equations for the reactions that take place at the following electrodes.

(i) electrode **B**

……..... [1]

(ii) electrode **C**

……..... [1]

(c) The same amount of current flows through the three electrolytic cells. 2.56 g of copper and 1.04 g of metal **X** are obtained.

(i) What is the mass of silver obtained?

mass of silver obtained …… g [3]

(ii) Determine the charge of the ions **X** and hence write the half equation for the discharge of solid X.

charge of ions **X** …… [2]

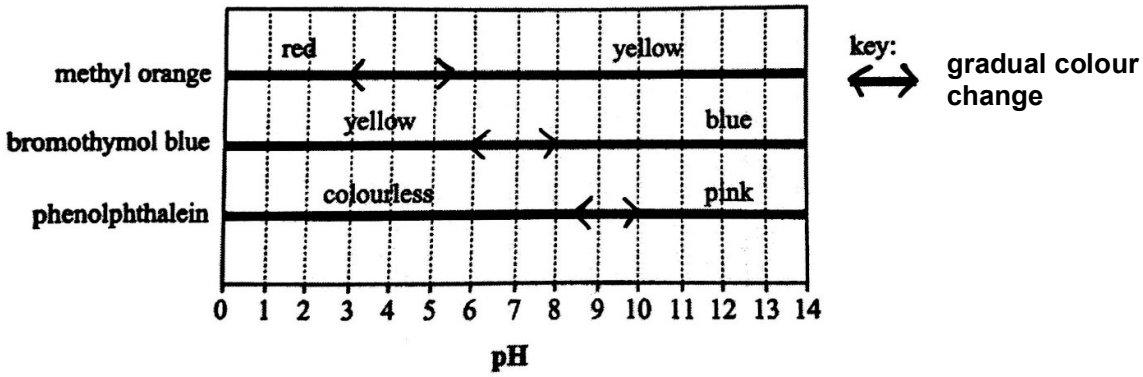
half equation ……..……..[1]

[Total: 10]

10 Acid-base indicators and end-point

Certain chemicals have the special property of appearing one colour when in a solution of one pH and a different colour when in a solution of a different pH. Such chemicals are known as **acid-base indicators**, or simply as **indicators** because, when a few drops of indicator are added to a solution, the colour of the solution serves as an indication of its pH. An endpoint is the point whereby an indicator changes colour during a titration. The table below shows the colours of three indicators at different pH values.

Table 10.1



Equivalence point

An equivalence point is the point at which the ratio of the number of moles of acid to that of the base is the same as that in a balanced chemical equation. The following graphs are obtained from the titrations of acids and bases of the same concentration using a pH probe and data logger.

End-point and equivalence point

The endpoint of a titration is not the same thing as the equivalence point. The equivalence point is a single point defined by the reaction stoichiometry as the point at which the base (or acid) added exactly neutralizes the acid (or base) being titrated. The endpoint is defined by the choice of indicator as the point at which the colour changes. Depending on how quickly the colour changes, the endpoint can occur almost instantaneously or be quite wide.

Titration curves

A plot showing the pH of the solution as a function of the quantity of base added is known as a titration curve. These plots can be constructed by plotting the pH as a function of the volume of base added. Although the strength of an acid has no effect on the location of the equivalence point, it does affect the *shape* of the titration curve and can be estimated on a plot of the curve. The figures below are examples of titration curves.

Titration 1

Titration between a strong acid (HC*l*) and a strong base (NaOH)

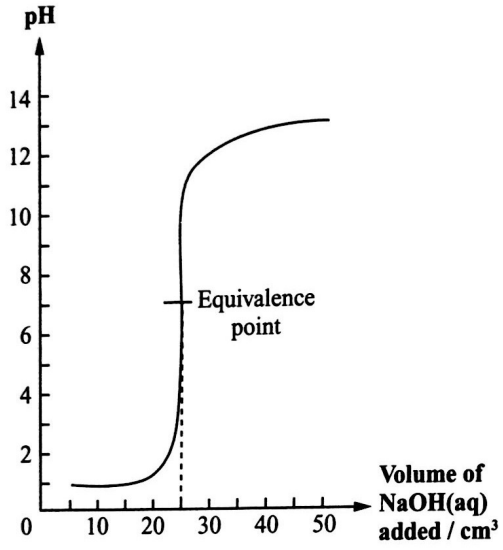


Fig. 10.1

Titration 2

Titration between a weak acid (CH_3COOH) and a strong base (NaOH)

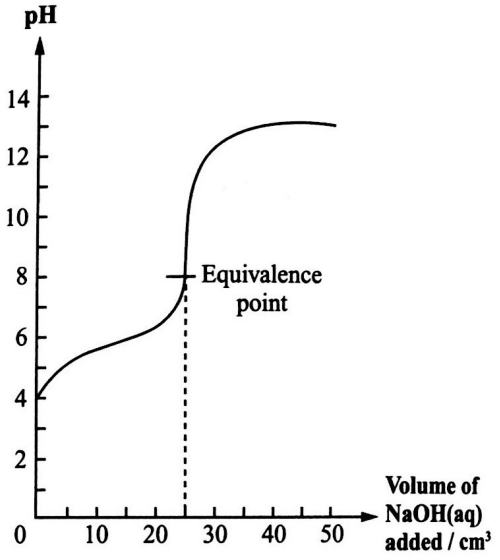


Fig. 10.2

Titration 3

Titration between a strong acid (HC*l*) and a weak base (NH_3 (aq))

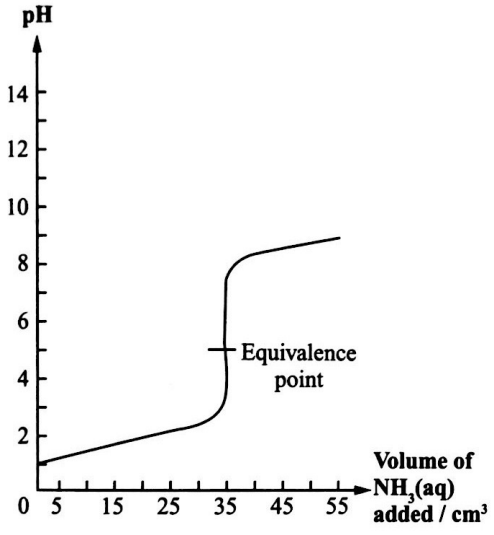


Fig. 10.3

Titration 4

Titration between a weak acid (CH_3COOH) and a weak base (NH_3 (aq))

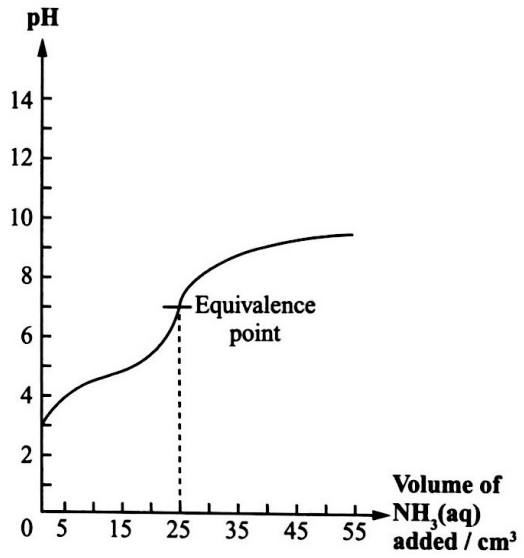


Fig. 10.4

(a) State whether the pH at the equivalence points of all the titrations always coincides with neutral pH. Explain your reasoning using the given information.

……

……

……

…… [2]

(b) Calculate the volume of hydrochloric acid used in titration 1 given that the concentration of the acid and the base is the same.

volume of hydrochloric acid used …… cm^3 [2]

(c) Bromothymol blue is used for titration 4.
Using Table 10.1 and Fig.10.4, find the volumes of NH_3 (aq) to reach end-point and equivalence point.

Hence, calculate the difference between the volume of NH_3 (aq) added between the end-point and the equivalence point.

difference in volume of NH_3 (aq) …… cm^3 [2]

(d) Phosphoric acid, H_3PO_4 is a weak acid that releases its H^+ in three different stages. The first two equivalence points when phosphoric acid was titrated with NaOH are shown in the graph in Fig. 10.5.

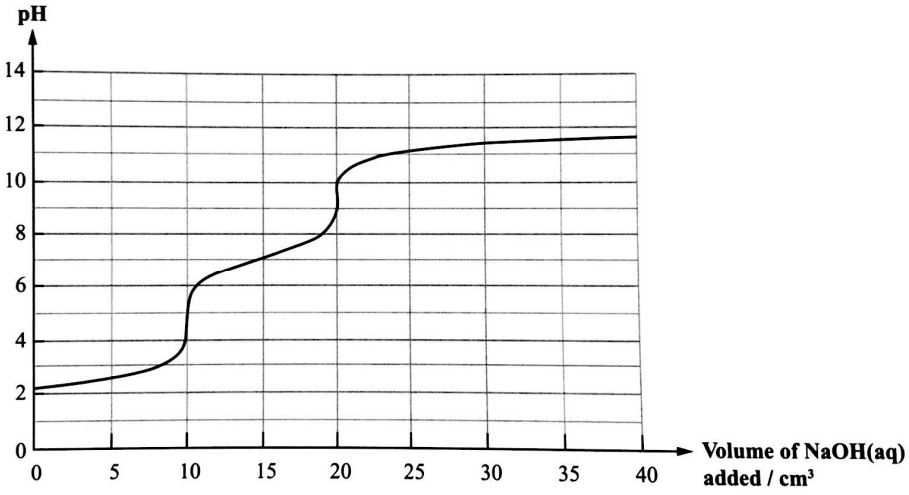


Fig. 10.5

(i) The following is the chemical equation for the first equivalence point.

$$NaOH\ (aq) + H_3PO_4\ (aq) \rightarrow NaH_2PO_4\ (aq) + H_2O\ (l)$$

Write the chemical equation for the second equivalence point.

……[1]

(ii) What is the pH values of the first two equivalence points?

First equivalence point ……

Second equivalence point …… [1]

(iii) State which indicators will be suitable to be used for the first and second equivalence points and explain why the three indicators cannot be used to find all three equivalence points.

……

……

……

…… [2]

[Total: 10]

Section B

Answer **one** question from this section.

11 A student investigated the reaction between 0.120 g of magnesium with 80.0 cm^3 of dilute hydrochloric acid.

The results of the experiment are shown in Table 11.1.

Table 11.1

experiment	concentration of acid (mol / dm^3)	temperature (°C)		form of magnesium	time taken for magnesium to react (s)
		before	after		
1	1.0	20	32	ribbon	100
2	1.0	20	32	small pieces	55
3	2.0	20	32	powder	10
4	2.0	40	50	ribbon	10

(a) **(i)** Calculate the maximum volume of hydrogen gas produced in experiment 2.

maximum volume of hydrogen …… dm^3 [2]

(ii) Explain how the total volume of hydrogen gas evolved would be affected with an addition of 20.0 cm^3 of copper (II) sulfate.

……

……

……[2]

(iii) State two reasons why experiment 4 is faster than experiment 1.

……

……

……[2]

(b) Another student decided to use aluminum ribbon instead of magnesium ribbon. It was found that the reaction took several minutes before bubbling starts. Explain this observation.

……..……...…….

……..……...…….

……..…

……..……..[2]

(c) The experiments were repeated in an identical manner but with sulfuric acid instead of hydrochloric acid. Explain how the initial rate of formation of hydrogen gas will be affected.

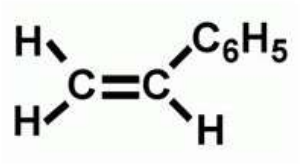
……..……...……

……..……

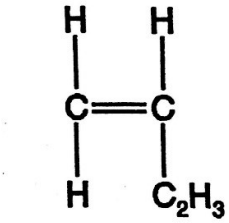
……..……..[2]

[Total: 10]

12 Styrene-butadiene rubber is a synthetic rubber. It is made by polymerising a mixture of the monomers butadiene and styrene. The structural formulae of the monomers are given.



styrene



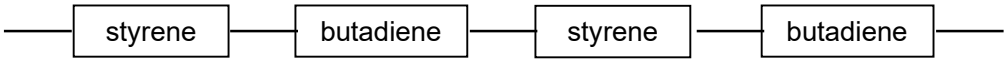
butadiene

(a) What type of polymerisation will take place when the monomers polymerise? Explain your answer.

……

……..[2]

(b) One possible structure for the polymer is shown below.



Give the full structural formula for the repeating unit in the polymer structure.

[1]

(c) When the mixture of styrene and butadiene polymerises, the polymer is unlikely to contain only this regular repeating pattern. Explain why.

……

……

……

……..[2]

(d) Butadiene can be made by cracking butane in a cracking tower.

(i) Butane cracks to form butadiene and one other product. Write an equation to show this reaction.

……..[1]

(ii) Give a use of the other product of this reaction.

……..[1]

(e) 2.90 kg of butane entered the cracking tower. After the reaction, 2.16 kg of butadiene had been made. Calculate the percentage yield of butadiene.

Percentage yield of butadiene…… [3]

[Total: 10]

End of Paper

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							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	3	4	5	6	7	8	9	10	11	12	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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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.).

The Avogadro constant, $L = 6.02 \times 10^{23}\ mol^{-1}$