ST. MARGARET'S SCHOOL (SECONDARY)

End-of-Year Examinations 2024

CANDIDATE NAME							
CLASS				REGISTER NUMBER			

CHEMISTRY **6092/02**

Paper 2 Theory **26 September 2024**

Secondary 3 Express **Paper 1 and 2: 2 hours**

Additional Materials: NIL

READ THESE INSTRUCTIONS FIRST

Write your name and register number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs, tables or rough working.
Do not use staples, paper clips, highlighter, glue or correction fluid.

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

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.
The use of an approved scientific calculator is expected, where appropriate.
A copy of the Periodic Table is printed on page **15**.

For Examiner's Use	
Total / 65 marks	

Answer **all** the questions in this section in the spaces provided.
The total mark for this section is 65.

1 Use only the substances below to answer the following questions.

lithium	sulfuric acid	carbon monoxide	iodine
copper(II) oxide	water	silicon dioxide	methane
bromine	hydrochloric acid	graphite	silicon

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

(a) Name **one** substance that has the same rate of diffusion as nitrogen gas.

..... [1]

(b) Name **one** substance which is a neutral oxide.

..... [1]

(c) Which **two** substances react to form a blue solution?

..... [1]

(d) Which **two** elements combine to form a solid that has a high melting point?

..... [1]

(e) Which **two** substances contain atoms arranged in a tetrahedral manner?

..... [1]

[Total: 5]

2 A sample of black ink contains a mixture of red, blue and yellow dyes. A solvent mixture of ethanol and water can be used to separate the dyes in the black ink. The coloured dyes have different R_f values in solvents with different compositions of ethanol as shown in the graph in **Fig 2.1**.

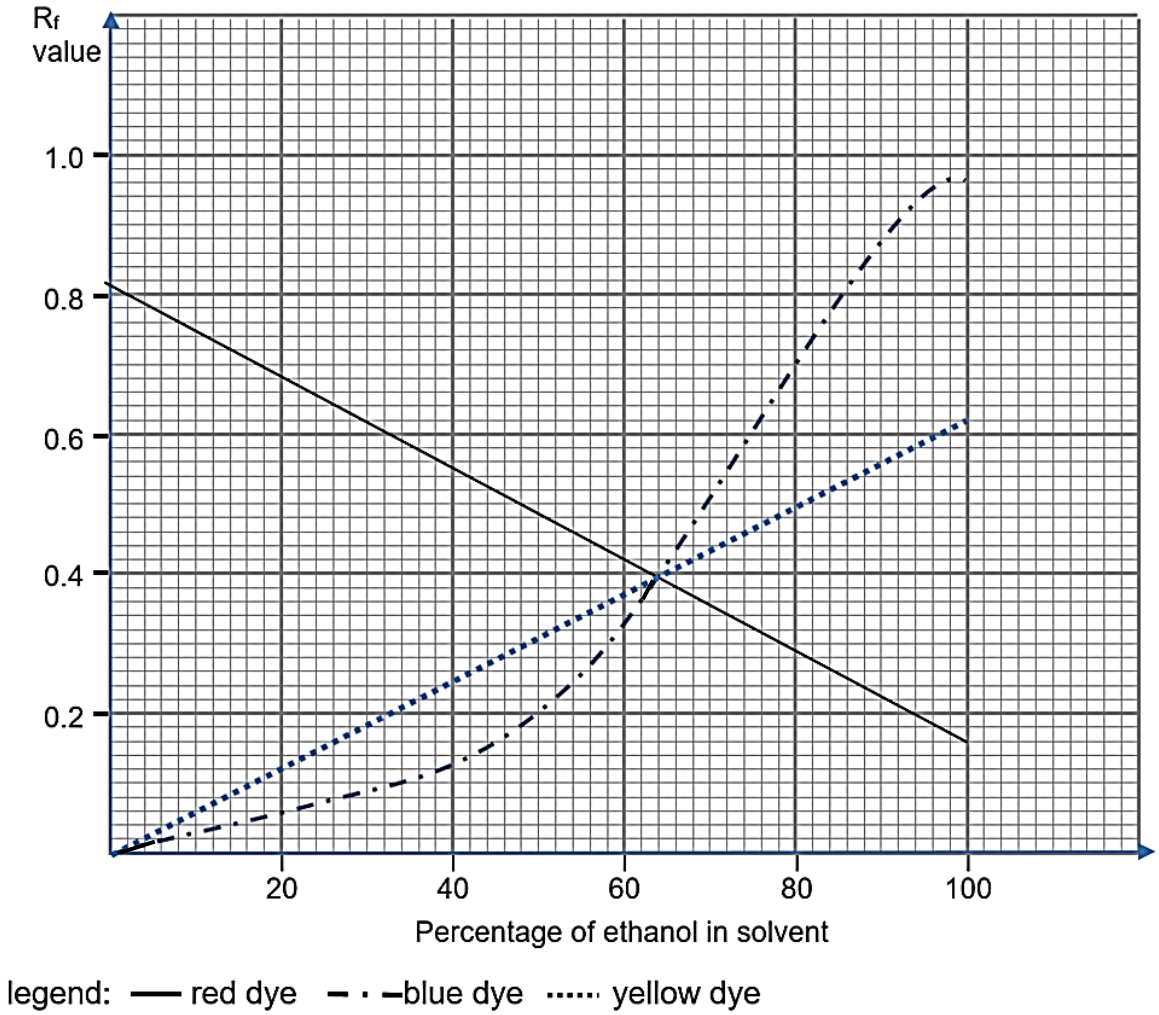


Fig 2.1

(a) Using information from the graph in **Fig 2.1**, explain why pure water would not be suitable for the separation of the black ink by using paper chromatography.

.....

.....

[2]

(b) A student carried out chromatography on the black ink using a certain mixture of ethanol and water as a solvent. The result showed only one spot on the chromatogram.

From the graph in **Fig 2,** state the percentages of ethanol **and** water in the solvent which the student used that resulted in only one spot.

.....

[1]

(c) The black ink was separated using 80% of ethanol.
What is the distance travelled by a spot of blue dye if the solvent front on the chromatogram is 10.0 cm? Show your working.

[2]

[Total:5]

3 Uranium exists as isotopes, uranium-235 and uranium-238. The relative abundance of the isotopes are: 0.7% uranium-235 and 99.3% uranium-238.

(a) Using your knowledge of Atomic Structure, explain why uranium-235 and uranium-238 are isotopes. State clearly the number of sub-atomic particles to support your answers.

.....

.....

[3]

.....

(b) Calculate the accurate average atomic mass of Uranium.

[2]

(c) The radioactive uranium-238 isotope will decay forming thorium-234 isotope and particle **X** according to the equation below.

$$^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{a}_{b}\boldsymbol{X}$$

Use the Periodic Table to identify particle $^{a}_{b}\boldsymbol{X}$.

[1]

.....

[Total:6]

4 Oxygen and chlorine combine to form a brownish-yellow gas, dichlorine monoxide (Cl_2O).
Oxygen and chlorine also combine with aluminium to form aluminium oxide and aluminium chloride respectively.

(a) Draw a "dot and cross" diagram to show the bonding in dichlorine monoxide. Show only the valence electrons.

[2]

(b) Aluminium oxide has a melting point of 2,072 °C while aluminium chloride has a melting point of 192.4 °C.

Using your understanding of bonding and structure, indicate with a tick (✓) whether the following statements are true or false.

	Statements	True	False
(i)	The ionic bonding in aluminum oxide is much stronger than in aluminium chloride.		
(ii)	Aluminium chloride has simple molecular structure while aluminium oxide has giant ionic lattice structure.		
(iii)	Both aluminum oxide and aluminium chloride can conduct electricity when molten.		

[3]

[Total:5]

5 Sodium hydride (NaH) is an ionic compound formed between sodium and hydrogen.

(a) Draw a dot and cross diagram to show the bonding in sodium hydride.
Show **all** electrons.

[2]

(b) In a reaction, 0.24 g of sodium hydride was reacted with 1.8 cm^3 of water which contained a few drops of Universal Indicator, to form sodium hydroxide solution and hydrogen gas at r.t.p.

(i) Write a balanced chemical equation for the above reaction.

[1]

.....

(ii) State the change in colour of the Universal Indicator in the reaction.

[1]

.....

(iii) Given the density of water is 1 g/cm^3, determine the limiting reactant of this reaction and hence calculate the number of moles of sodium hydroxide formed.

[3]

[Total:7]

6 **(a)** Ethanedioic acid is a colourless crystalline solid with the formula $H_2C_2O_4$. It is an organic compound with a melting point of 103°C.
A student tested the electrical conductivity of his sample of ethanedioic acid and found that the colourless acid crystals did not conduct electricity. However, he found that the aqueous solution of the acid could conduct electricity.
Explain why the pure acid does not conduct electricity but can do so when dissolved in water.

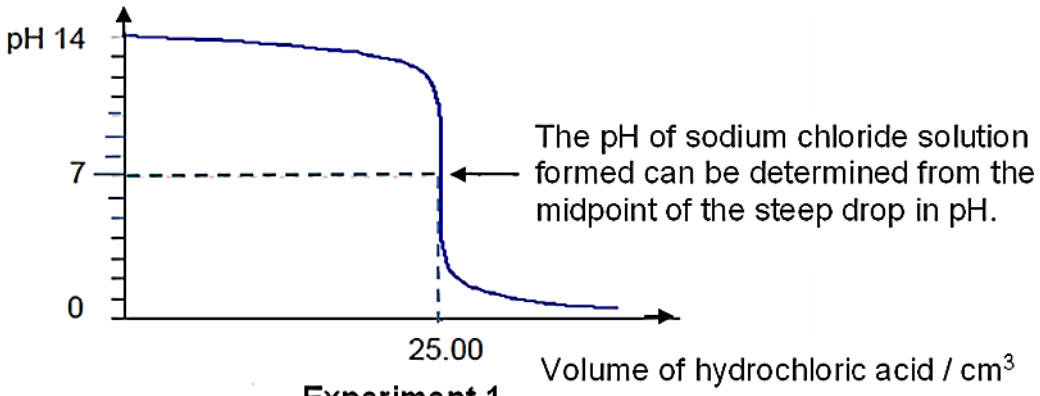
.....

.....

.....

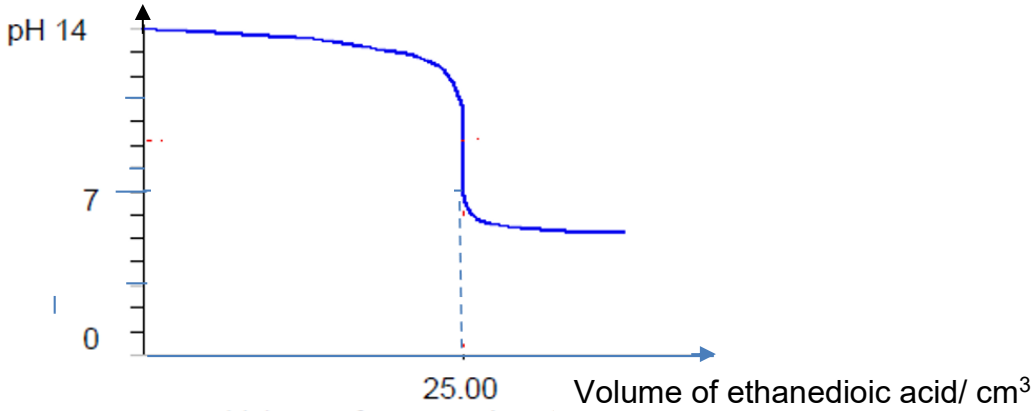
[2]

(b) A pH datalogger measures pH changes during some titration experiments.
In **Experiment 1**, dilute hydrochloric acid was added from a burette to 20.0 cm^3 of 0.200 mol/dm^3 aqueous sodium hydroxide.
The pH datalogger results are shown in **Fig 6.1**.



Experiment 1
Fig 6.1

Experiment 2 is carried out by titrating ethanedioic acid with a solution of sodium hydroxide of the same concentration and volume as that used in **Experiment 1**.
The pH datalogger results are shown in **Fig 6.2**.



Experiment 2
Fig 6.2

(i) Use the information given in **Fig 6.1** to calculate the concentration of dilute hydrochloric acid used in **Experiment 1**.

[2]

(ii) Sodium ethanedioate solution was obtained in **Experiment 2**.
Use the information in **Fig 6.2** to determine the pH of sodium ethanedioate solution.

[1]

.....

(iii) A list of indicators with the pH range at which it changes colour is given.

iIndicators	Colour change	pH range at which colour change occurs
Bromothymol blue	Yellow - blue	6.0 - 7.6
Litmus	Red - blue	5.0 - 8.0
Methyl orange	Red - orange	3.1 - 4.4
Phenolphthalein	Colourless - red	8.2 - 9.8
Thymol blue	Red - yellow	1.2 - 2.8

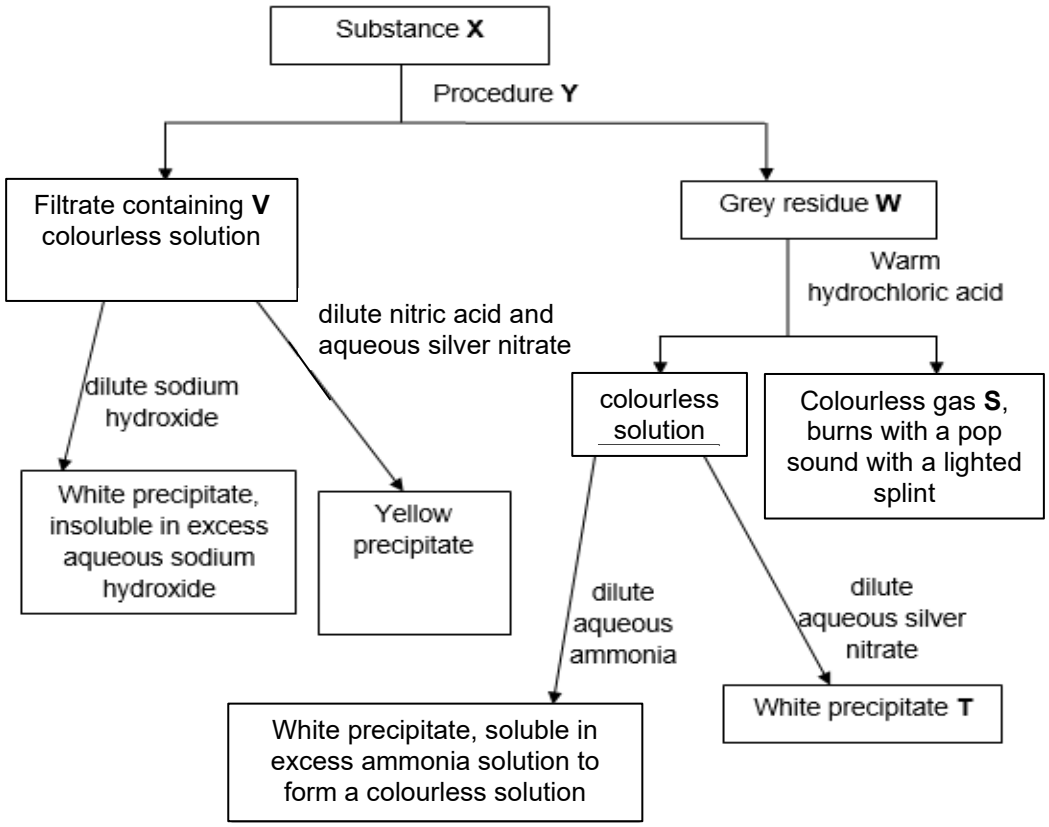
Identify **two** suitable indicators that could be used to determine the end-points of both experiments **1** and **2**.

[2]

.....

[Total: 7]

7 Substance **X** is a mixture of two solids, **V** and **W**.
The flowchart below shows some procedures performed on substance **X**.



(a) Outline procedure **Y**.

.....

]2]

.....

(b) Identify substances **S**, **V** and **W**

S: …….

V:……..

W:……

[3]

(c) Write an ionic equation for the reaction in which substance **T** was formed.

[1]

.....

[Total:6]

8 Acidified potassium manganate(VII) reacts with aqueous hydrogen peroxide. The equation for the reaction is given below:

$5H_2O_2\,(aq) + 2MnO_4^-(aq) + 6H^+\,(aq) \rightarrow 5O_2\,(g) + 2Mn^{2+}\,(aq) + 8H_2O\,(l)$

(a) State the oxidation number of manganese in the following ions.

(i) MnO_4^- : .....

(ii) Mn^{2+} : .....

[2]

(b) State **two** changes you would expect to observe when acidified potassium manganate(VII) is added to aqueous hydrogen peroxide.

.....

.....

[2]

(c) Is hydrogen peroxide oxidized or reduced? Explain your answer in terms of change in oxidation number.

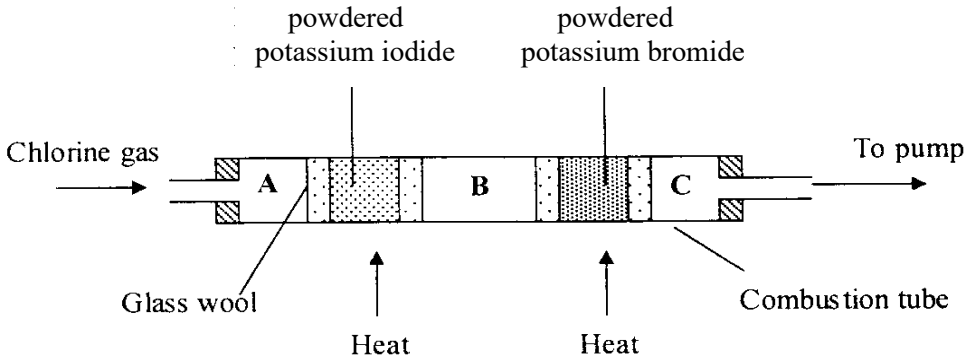
.....

.....

[2]

[Total: 6]

9 To study the relative reactivity of halogens, chlorine gas was pumped into the apparatus shown below.



(a) A student observed that a coloured gas was formed at **B** in the apparatus. State the colour of this gas and write a balanced chemical equation for the reaction that produced this gas.

Colour of the gas: ..... [1]

Chemical equation ..... [1]

(b) Black deposits were observed on the cooler parts of the apparatus at **C**.

(i) State the identity of the black deposits

.....

[1]

(ii) Explain the observation at **C**.

.....

.....

[2]

(c) Astatine is a halogen. Write the formula of the ion formed by astatine during chemical bonding.

.....

[1]

[Total: 6]

10 Three experiments were set up to investigate the factors that affect the rate of rusting in iron are shown in **Fig 10.1**.

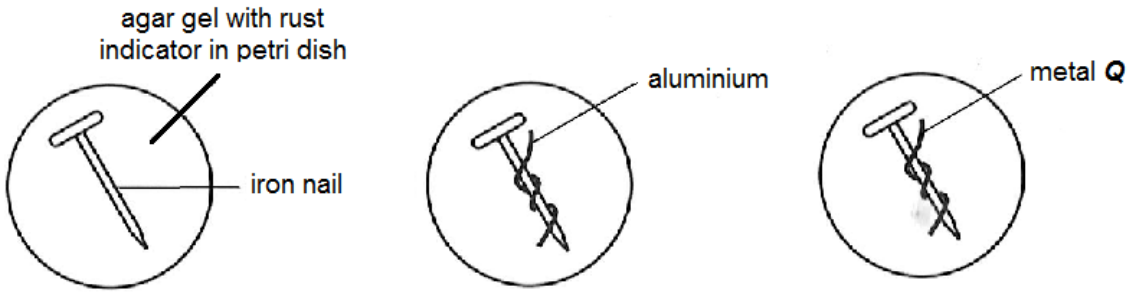


Fig 10.1

Agar gel with a few drops of rust indicator is placed in all the petri dishes. If the rusting of iron occurs, the indicator turns blue.
The table below shows the results of experiments 1 and 3 after a week.

Experiment	Observation
1	Small blue patches were formed around the nail.
2	
3	Large blue patches were formed around the nail.

(a) State the conditions required for rusting of iron to take place.

.....

[1]

(b) Using the observation in **experiment 3**, what can you conclude about metal **Q** ? Explain your answer.

.....

[2]

.....

(c) **(i)** Aluminium used in the experiment was cleaned with sand paper. Explain why this is necessary.

[1]

.....

(ii) Suggest an observation for **experiment 2**.

[1]

.....

[Total:5]

11 An alloy is a mixture of a metal with one or a few other elements. Some common alloys include steel, brass and bronze.

Steel is a very important class of alloys. The many types of steel are primarily composed of iron, with various amounts of the elements such as carbon, chromium, manganese, nickel, molybdenum and boron. Depending on the amount of carbon and other metals added, as well as the type of metals added to iron, each type of steel has its own special properties and uses.

Different types of steel can be classified using a standard alloy numbering system known as the SAE steel grades. Each type of steel is designated a four-digit number, whereby the first two digits indicate the type of steel and the last two digits indicate the percentage of carbon by weight.

For example, a 1060 steel is a plain carbon steel containing 0.60 % by weight of carbon. Table **11.1** shows some examples of steels and their SAE designation.

Table 11.1

type of steel	SAE designation	amount of element present
carbon steel	1060	0.60% carbon
nickel steel	23XX	Ni 3.50 % (other than carbon)
molybdenum steel	40XX	Mo 0.25 % (other than carbon)
chromium steel	50XX	Cr 0.27 % (other than carbon)

Table 11.2 shows the composition, approximate melting point and use of some common types of carbon steels.

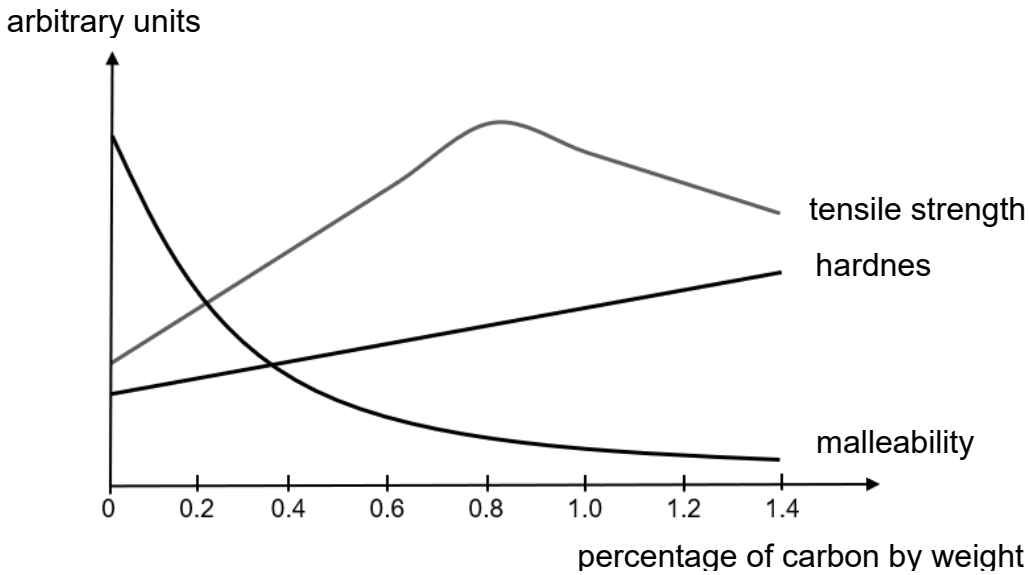
Table 11.2

type of carbon steel	percentage of carbon	approximate melting point / °C	use
low carbon	0.05 – 0.30	~ 1464	car bodies
medium carbon	0.30 – 0.60	~ 1427	machinery
high carbon	0.60 – 1.00	~ 1353	wire ropes for suspension bridges

Tensile strength can be used as an indicator of the strength of alloys. It is measured by the maximum stress that a material can withstand while being stretched or pulled before breaking

Graph 11.3 shows the correlation between the percentage of carbon by weight in carbon steels and their tensile strength, hardness as well as malleability.

Graph 11.3



Reference:
https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Book%3A_Introductory_Chemistry_(CK-12)/08%3A_Ionic_and_Metallic_Bonding/8.12%3A_Alloys

(a) Use information from **Table 11.1** to write the SAE designation for a chromium steel containing 0.65 % by weight of carbon.

[1]

.....

(b) Use relevant data from **Table 11.2** and **Graph 11.3** to explain why low carbon steel and high carbon steel are suitable for their respective uses.

low carbon steel:

.....

.....

high carbon steel

.....

.....

.....

[2]

(c) **(i)** Identify which carbon steel from **Table 11.2** is the hardest.

.....

[1]

(**ii)** Explain with reference to the structure present in the carbon steel, why your answer in **(c)(i)** is harder than the other carbon steels.

.....

.....

.....

.....

.....

.....

[3]

[Total:7]

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 x 10^{23} mol