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CHEMISTRY

5070/22

Paper 2 Theory

October/November 2015

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name 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.

DO NOT WRITE IN ANY BARCODES.

Section A

Answer **all** questions.

Write your answers in the spaces provided in the Question Paper.

Section B

Answer any **three** questions.

Write your answers in the spaces provided in the Question Paper.

Electronic calculators may be used.

You may lose marks if you do not show your working or if you do not use appropriate units.

A copy of the Periodic Table is printed on page 20.

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.

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

Section A

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

The total mark for this section is 45.

A1 Choose from the following elements to answer the questions below.

aluminium
argon
carbon
copper
iodine
iron
lead
magnesium
nitrogen
oxygen
sulfur

Each of these elements can be used once, more than once or not at all.

Which element

(a) has an ion which, in aqueous solution, reacts with aqueous sodium hydroxide to give a red-brown precipitate,

.....[1]

(b) has an atom with an electronic configuration with only five occupied electron shells,

.....[1]

(c) has an oxide which decolourises acidified potassium manganate(VII),

.....[1]

(d) has a sulfate which is insoluble in water,

.....[1]

(e) provides an inert atmosphere for the extraction of reactive metals,

.....[1]

(f) produces ammonia when it is warmed with an aqueous mixture of sodium nitrate and sodium hydroxide?

.....[1]

[Total: 6]

A2 Plants contain many different types of carbon compounds.

(a) Carbon compounds are made in plants by photosynthesis.

Write the overall equation for photosynthesis and state the conditions required for this process.

.....
.....
.....[3]

(b) Starch is a polymer found in plants.
Starch can be hydrolysed.

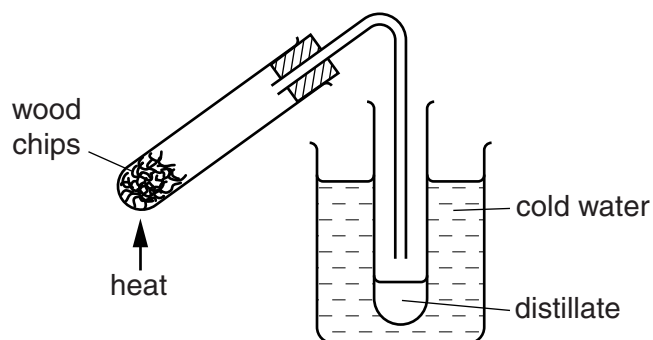
(i) Give the name of the product formed when starch is hydrolysed.

.....[1]

(ii) Give the reagent and conditions needed to hydrolyse starch.

.....[2]

(c) When wood chips are heated in the absence of air, a colourless distillate is formed.



The distillate contains ethanoic acid, esters and other organic compounds.

(i) Ethanoic acid reacts with calcium hydroxide to form a salt and water.

Give the name and formula of the salt formed.

name

formula [2]

(ii) One of the esters in the distillate has the molecular formula, $C_4H_8O_2$.

Draw the structure of an ester with this formula, showing all the atoms and all the bonds.

[1]

(iii) The distillate also contains a compound with the following composition.

| element | percentage by mass |
|----------|--------------------|
| carbon | 37.5 |
| hydrogen | 12.5 |
| oxygen | 50.0 |

Deduce the empirical formula of this compound.

empirical formula[2]

[Total: 11]

A3 Water for use in the home is treated using carbon and chlorine.

(a) Explain the purpose of using carbon and chlorine in water treatment.

carbon.....

chlorine [2]

(b) In some parts of the world, drinking water is purified by desalination.

What is meant by the term *desalination*?

..... [1]

(c) River water may contain pollutants from agricultural sources.
These pollutants may cause eutrophication.

Give the names of two anions present in fertilisers which contribute to eutrophication.

..... and [1]

(d) An aqueous solution of barium chloride is added to a sample of water which contains sulfate ions. A white precipitate forms.

Construct an ionic equation, including state symbols, for this reaction.

..... [2]

[Total: 6]

A4 Iron is extracted in a blast furnace. The raw materials required are

- iron ore, which contains iron(III) oxide, Fe_2O_3 ,
- limestone,
- coke (carbon),
- air.

- (a)** The coke first burns in air to form carbon dioxide.
The carbon dioxide is then reduced by coke to produce carbon monoxide.
The carbon monoxide reduces the iron(III) oxide to iron.

Write equations for

- (i)** the reduction of carbon dioxide by coke,

.....[1]

- (ii)** the reduction of iron(III) oxide to iron by carbon monoxide.

.....[1]

- (b)** Why is limestone added to the blast furnace?

.....[1]

- (c)** Another ore of iron contains an oxide with the formula Fe_3O_4 .

Calculate the percentage by mass of iron in Fe_3O_4 .

[2]

- (d) Iron can be obtained by the electrolysis of an aqueous acidified solution of iron(II) sulfate. The reactions at the electrodes are given.



Which reaction is oxidation and which is reduction? Explain your answer.

.....
.....
.....[2]

- (e) Attaching magnesium strips to the iron hulls of ships can lower their rate of rusting.

Explain how the magnesium stops the iron from rusting.

.....
.....
.....
.....[2]

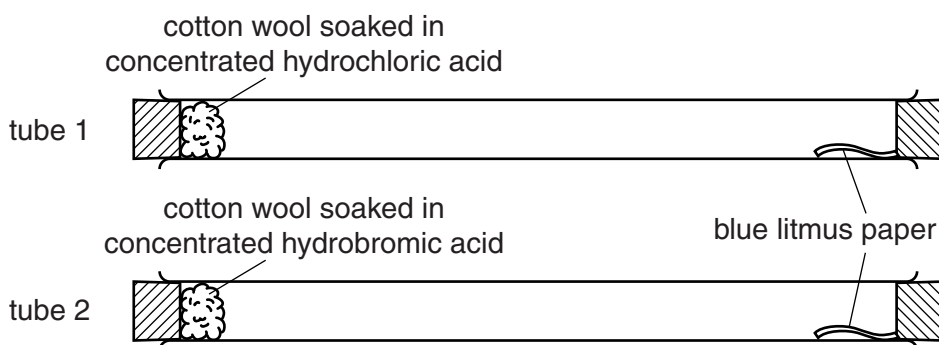
- (f) Aqueous iron(II) chloride is one of the products formed when iron reacts with hydrochloric acid.

Construct an equation for this reaction.

.....[1]

[Total: 10]

A5 (a) Two students set up tubes as shown.



Concentrated hydrochloric acid produces fumes of hydrogen chloride.
 Concentrated hydrobromic acid produces fumes of hydrogen bromide.

Four minutes after setting up the experiment, the litmus paper in tube 1 turns red.
 Seven minutes after setting up the experiment, the litmus paper in tube 2 turns red.

Use the kinetic particle theory to explain

(i) how the gases move through the tubes,

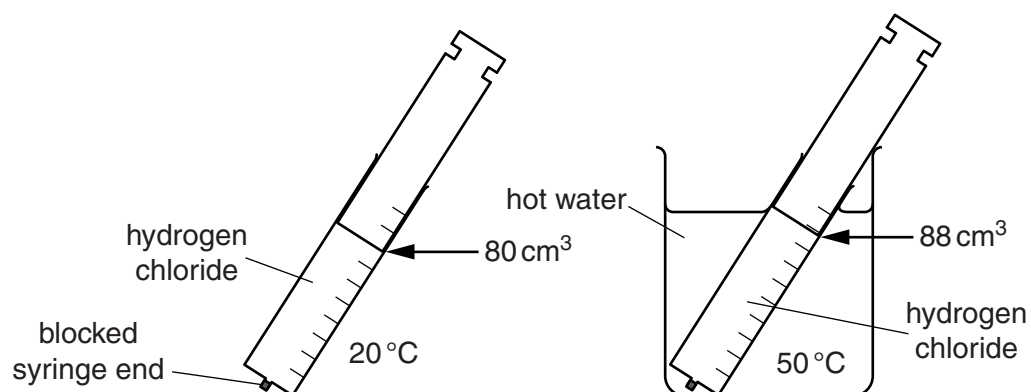
.....

 [2]

(ii) why the gases take different times to reach the litmus paper.

.....
 [1]

- (b) A gas syringe is filled with 80 cm^3 of hydrogen chloride gas at 20°C . The syringe is placed in some hot water at 50°C . The atmospheric pressure does not change but the volume of the gas in the syringe increases to 88 cm^3 .



Use the kinetic particle theory to explain why the volume increases.

.....

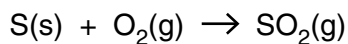
.....

.....

.....[2]

[Total: 5]

A6 When one mole of sulfur burns, 247 kJ of energy is released.



(a) Calculate the energy released when 9.60 g of sulfur is burnt.

[2]

(b) When sulfur dioxide is passed through aqueous sodium hydroxide, sodium hydrogensulfite is formed. Sodium hydrogensulfite contains the hydrogensulfite ion, HSO_3^- .

Construct the ionic equation for this reaction.

.....[1]

(c) The hydrogensulfite ion is a weaker acid than ethanoic acid.

Samples of 0.1 g of magnesium are added separately to 0.1 mol/dm^3 ethanoic acid and 0.1 mol/dm^3 hydrogensulfite ions.

Explain why the reaction is faster with ethanoic acid.

.....

[2]

(d) Calculate the volume of 0.10 mol/dm^3 sodium hydroxide which contains 3.2 g of sodium hydroxide.

volume of aqueous sodium hydroxide = cm^3 [2]

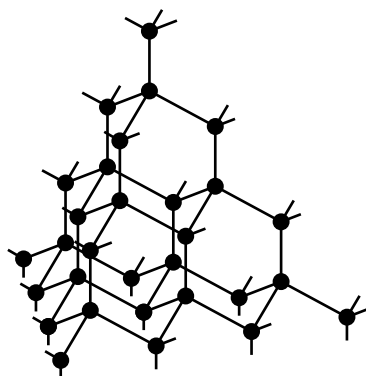
[Total: 7]

Section B

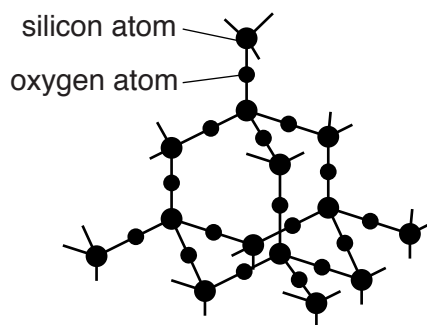
Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

B7 The structures of diamond and silicon dioxide are shown.



diamond



silicon dioxide

(a) Describe one similarity in the structures of diamond and silicon dioxide.

.....[1]

(b) Explain why silicon dioxide has a high melting point.

.....

.....[2]

(c) Silicon dioxide reacts with hot concentrated sodium hydroxide to form sodium silicate, Na_2SiO_3 .

Deduce the formula of the silicate ion.

.....[1]

(d) Explain why diamond does not conduct electricity.

.....[1]

(e) Graphite is a form of carbon which conducts electricity.
Graphite is used as electrodes in electrolysis.

What is the meaning of the term *electrolysis*?

.....

.....[1]

- (f) Aluminium is extracted by the electrolysis of molten aluminium oxide dissolved in cryolite.

Construct the equation for the reaction at

- (i) the anode (positive electrode),

.....[1]

- (ii) the cathode (negative electrode).

.....[1]

- (g) An isotope of silicon is represented by the symbol ${}_{14}^{29}\text{Si}$.

Deduce the number of protons and neutrons in this isotope.

number of protons

number of neutrons[1]

- (h) Silicon has a relative atomic mass of 28.

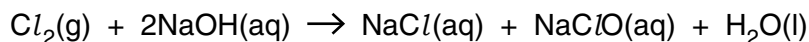
Define the term *relative atomic mass*.

.....

.....[1]

[Total: 10]

B8 Chlorine reacts with sodium hydroxide.



- (a) A volume of 144 cm³ of chlorine gas, measured at room temperature and pressure, is passed into 38.0 cm³ of 0.250 mol/dm³ sodium hydroxide.

Show by calculation which reactant is in excess.

[3]

- (b) Chlorine displaces bromine from an aqueous solution of potassium bromide.

- (i) Construct the equation for this reaction.

.....[2]

- (ii) Explain why bromine does not react with aqueous potassium chloride.

.....
[1]

- (iii) Give the charge of a chloride ion and its electronic configuration.

charge

electronic configuration[2]

- (c) Explain why sodium chloride does not conduct electricity when solid but does conduct electricity when molten.

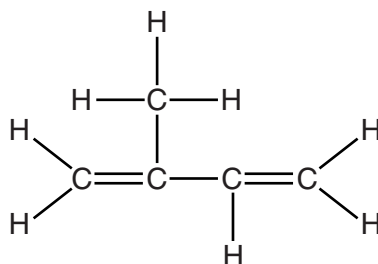
.....

[2]

[Total: 10]

Question B9 begins on page 16.

- B9** When rubber is heated in the absence of air, a small amount of isoprene is formed. The structure of isoprene is shown.



- (a)** Isoprene is an unsaturated hydrocarbon.

Describe a test for an unsaturated hydrocarbon.

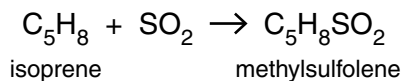
.....
 [2]

- (b)** Isoprene is a liquid at 25°C.

Describe the arrangement and motion of the particles in isoprene at 25°C.

.....
 [2]

- (c)** Isoprene reacts with sulfur dioxide to form methylsulfolene.



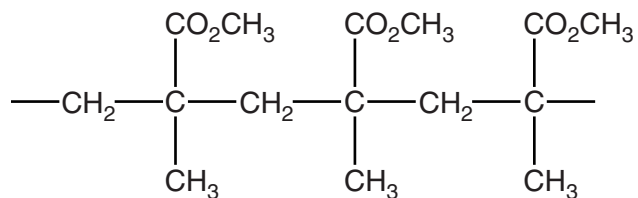
Calculate the maximum mass of methylsulfolene that can be formed from 100 g of isoprene.

mass of methylsulfolene = g [3]

- (d) (i) What feature of the isoprene molecule is responsible for it forming an addition polymer?

.....[1]

- (ii) *Perspex* is also an addition polymer.
The diagram shows part of the polymer chain of *Perspex*.

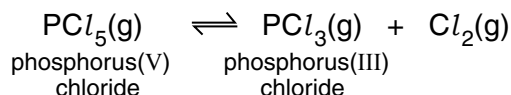


Deduce the formula of the monomer used to make *Perspex*.

[2]

[Total: 10]

B10 At 200°C and 200 atmospheres pressure, phosphorus(V) chloride forms an equilibrium mixture with phosphorus(III) chloride and chlorine.



- (a) Predict and explain the effect of decreasing the pressure on the position of this equilibrium. The temperature remains constant.

.....

 [2]

- (b) Predict and explain the effect of increasing the concentration of chlorine on the position of this equilibrium.

.....

 [2]

- (c) The table shows the percentage of phosphorus(III) chloride in the equilibrium mixture at different temperatures. The pressure is the same in each case.

| temperature/°C | % PCl ₃ in the mixture |
|----------------|-----------------------------------|
| 200 | 48 |
| 300 | 95 |
| 400 | 99 |

- (i) Describe how the composition of this equilibrium mixture changes with temperature.

.....
 [1]

- (ii) Explain what this tells you about the energy change in this reaction.

.....
 [1]

(d) How is the position of equilibrium affected by the presence of a catalyst?

.....[1]

(e) The rate of this reaction increases with increase in temperature.
Explain why.

.....
.....
.....
.....[2]

(f) Phosphorus(V) chloride reacts with water. Phosphoric acid, H_3PO_4 , and hydrogen chloride are formed.

Construct the equation for this reaction.

.....[1]

[Total: 10]

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DATA SHEET
The Periodic Table of the Elements

| I | | II | | Group | | | | | | | | | | III | | IV | | V | | VI | | VII | | O | | | |
|------------------------------------|------------------------------------|-------------------------------------|------------------------------------|------------------------------------|--|-------------------------------------|--------------------------------------|-------------------------------------|-------------------------------------|--------------------------------------|-------------------------------------|---------------------------------------|---------------------------------------|------------------------------------|--|-------------------------------------|---------------------------------------|---|--|----|--|-----|--|-------------------------------------|--|-------------------------------|--|
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | 1 H Hydrogen 1 | | | | | | | | | | | | 4 He Helium 2 | |
| 7 Li Lithium 3 | 9 Be Beryllium 4 | | | | | | | | | | | | | | | | | | | | | | | 20 Ne Neon 10 | | | |
| 23 Na Sodium 11 | 24 Mg Magnesium 12 | | | | | | | | | | | | | | | | | | | | | | | 35.5 Cl Chlorine 17 | | | |
| 39 K Potassium 19 | 40 Ca Calcium 20 | 45 Sc Scandium 21 | 48 Ti Titanium 22 | 51 V Vanadium 23 | 52 Cr Chromium 24 | 55 Mn Manganese 25 | 56 Fe Iron 26 | 59 Co Cobalt 27 | 59 Ni Nickel 28 | 64 Cu Copper 29 | 65 Zn Zinc 30 | 70 Ga Gallium 31 | 73 Ge Germanium 32 | 75 As Arsenic 33 | 79 Se Selenium 34 | 80 Br Bromine 35 | 84 Kr Krypton 36 | | | | | | | | | | |
| 85 Rb Rubidium 37 | 88 Sr Strontium 38 | 89 Y Yttrium 39 | 91 Zr Zirconium 40 | 93 Nb Niobium 41 | 96 Mo Molybdenum 42 | 101 Ru Ruthenium 44 | 106 Pd Palladium 46 | 108 Ag Silver 47 | 112 Cd Cadmium 48 | 115 In Indium 49 | 119 Sn Tin 50 | 122 Sb Antimony 51 | 127 I Iodine 53 | 131 Xe Xenon 54 | | | | | | | | | | | | | |
| 133 Cs Caesium 55 | 137 Ba Barium 56 | 139 La Lanthanum 57 | 178 Hf Hafnium 72 | 181 Ta Tantalum 73 | 184 W Tungsten 74 | 190 Os Osmium 76 | 195 Pt Platinum 78 | 197 Au Gold 79 | 201 Hg Mercury 80 | 204 Tl Thallium 81 | 207 Pb Lead 82 | 209 Bi Bismuth 83 | 210 At Astatine 85 | 222 Rn Radon 86 | | | | | | | | | | | | | |
| 223 Fr Francium 87 | 226 Ra Radium 88 | 227 Ac Actinium 89 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | 140 Ce Cerium 58 | 141 Pr Praseodymium 59 | 144 Nd Neodymium 60 | 147 Pm Promethium 61 | 150 Sm Samarium 62 | 152 Eu Europium 63 | 157 Gd Gadolinium 64 | 159 Tb Terbium 65 | 162 Dy Dysprosium 66 | 165 Ho Holmium 67 | 167 Er Erbium 68 | 169 Tm Thulium 69 | 173 Yb Ytterbium 70 | 175 Lu Lutetium 71 | | | | | | | | | | |
| | | | | 232 Th Thorium 90 | 231 Pa Protactinium 91 | 238 U Uranium 92 | 237 Np Neptunium 93 | 244 Pu Plutonium 94 | 243 Am Americium 95 | 247 Cm Curium 96 | 247 Bk Berkelium 97 | 251 Cf Californium 98 | 252 Es Einsteinium 99 | 257 Fm Fermium 100 | 258 Md Mendelevium 101 | 259 No Nobelium 102 | 260 Lr Lawrencium 103 | | | | | | | | | | |

* 58–71 Lanthanoid series
† 90–103 Actinoid series

Key

| | |
|---|----------|
| a | X |
| b | |
| † | |

a = relative atomic mass
X = atomic symbol
b = atomic (proton) number

The volume of one mole of any gas is 24dm³ at room temperature and pressure (r.t.p.).