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CHEMISTRY

0971/42

Paper 4 Theory (Extended)

October/November 2018

1 hour 15 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.

Answer **all** questions.

Electronic calculators may be used.

A copy of the Periodic Table is printed on page 16.

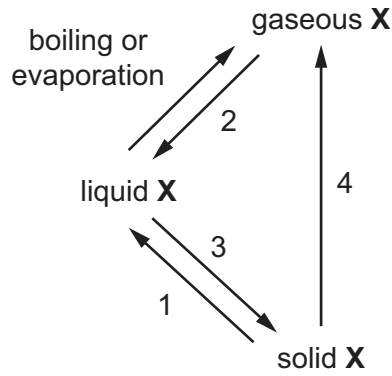
You may lose marks if you do not show your working or if you do not use appropriate units.

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 **13** printed pages and **3** blank pages.

1 Element X can undergo the following physical changes.



(a) (i) Give the scientific name for each of the numbered physical changes.

- 1
- 2
- 3
- 4 [4]

(ii) Explain why the changes shown are physical changes.

..... [1]

(iii) One difference between boiling and evaporation is the rate at which the processes occur. State **one** other difference between boiling and evaporation.

..... [1]

(b) Describe the separation, arrangement and motion of particles of element X in the solid state.

separation

arrangement

motion [3]

(c) Element X is a Group I metal. It burns in air to form an oxide X_2O .

Write a chemical equation for this reaction.

..... [2]

[Total: 11]

2 Magnesium, calcium and strontium are Group II elements.

(a) Complete the table to show the arrangement of electrons in a calcium atom.

shell number	1	2	3	4
number of electrons				

[1]

(b) Describe how the arrangement of electrons in a strontium atom is:

(i) similar to the arrangement of electrons in a calcium atom

.....

(ii) different from the arrangement of electrons in a calcium atom.

.....

[2]

(c) Calcium reacts with cold water to form two products:

- a colourless gas, **P**, which 'pops' with a lighted splint
- a weakly alkaline solution, **Q**, which turns milky when carbon dioxide is bubbled through it.

(i) Name gas **P**.

..... [1]

(ii) Identify the ion responsible for making solution **Q** alkaline.

..... [1]

(iii) Suggest the pH of solution **Q**.

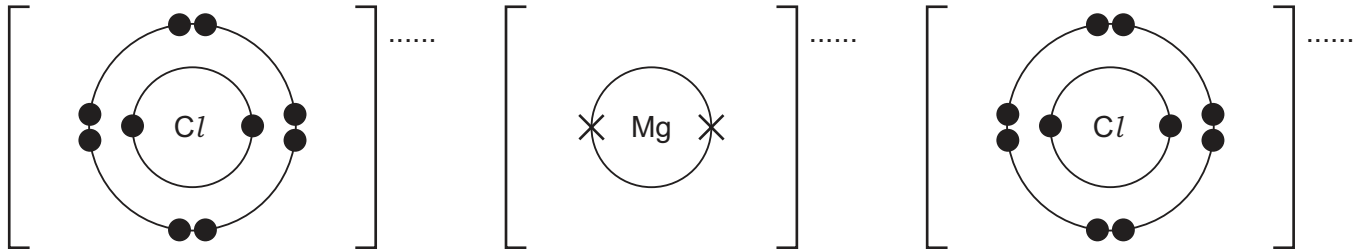
..... [1]

(iv) Write a chemical equation for the reaction of calcium with cold water.

..... [2]

(d) Magnesium reacts with chlorine to form magnesium chloride, MgCl_2 . Magnesium chloride is an ionic compound.

(i) Complete the diagrams to show the electronic structures of the ions in magnesium chloride. Show the charges on the ions.



[3]

(ii) Give **three** physical properties that are typical of ionic compounds such as MgCl_2 .

1

2

3

[3]

(e) Aqueous magnesium chloride is added to aqueous silver nitrate. A white precipitate forms.

Write an **ionic** equation for this reaction. Include state symbols.

..... [2]

[Total: 16]

3 Sulfur is an important element.

(a) Explain how burning fossil fuels containing sulfur leads to the formation of acid rain.

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

(b) Sulfuric acid is manufactured by the Contact process. One step in the Contact process involves a reversible reaction in which sulfur trioxide, SO_3 , is formed.

(i) Write a chemical equation for this reversible reaction. Include the correct symbol to show that the reaction is reversible.

..... [2]

(ii) State the conditions and name the catalyst used in this reversible reaction.

temperature

pressure

catalyst

[3]

(iii) Describe how the sulfur trioxide formed is converted into sulfuric acid in the next steps of the Contact process.

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

(c) Dilute sulfuric acid is used to make salts known as sulfates.

A method consisting of three steps is used to make zinc sulfate from zinc carbonate.

step 1 Add an excess of zinc carbonate to 20 cm³ of 0.4 mol/dm³ dilute sulfuric acid until the reaction is complete.

step 2 Filter the mixture.

step 3 Heat the filtrate until a saturated solution forms and then allow it to crystallise.

(i) Name a suitable piece of apparatus for measuring 20 cm³ of dilute sulfuric acid in **step 1**.

..... [1]

(ii) State **two** observations which would show that the reaction is complete in **step 1**.

1

2 [2]

(iii) Why is it important to add an excess of zinc carbonate in **step 1**?

..... [1]

(iv) What is meant by the term *saturated solution* in **step 3**?

..... [2]

(v) The equation for the reaction is shown.



Complete the equation by inserting the state symbol for zinc sulfate. [1]

(vi) Name another zinc compound which could be used to make zinc sulfate from dilute sulfuric acid using this method.

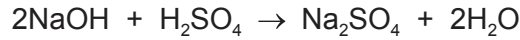
..... [1]

(vii) Suggest why this method would **not** work to make barium sulfate from barium carbonate and dilute sulfuric acid.

..... [1]

- (d) In a titration, a student added 25.0 cm³ of 0.200 mol/dm³ aqueous sodium hydroxide to a conical flask. The student then added a few drops of methyl orange to the solution in the conical flask.

Dilute sulfuric acid was then added from a burette to the conical flask. The volume of dilute sulfuric acid needed to neutralise the aqueous sodium hydroxide was 20.0 cm³.



- (i) What was the colour of the methyl orange in the aqueous sodium hydroxide?

..... [1]

- (ii) Determine the concentration of the dilute sulfuric acid in g/dm³.

- Calculate the number of moles of aqueous sodium hydroxide added to the conical flask.

..... mol

- Calculate the number of moles of dilute sulfuric acid added from the burette.

..... mol

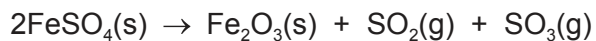
- Calculate the concentration of the dilute sulfuric acid in mol/dm³.

..... mol/dm³

- Calculate the concentration of the dilute sulfuric acid in g/dm³.

..... g/dm³
[4]

(e) Iron(II) sulfate decomposes when heated strongly.



15.20 g of $\text{FeSO}_4(\text{s})$ was heated and formed 4.80 g of $\text{Fe}_2\text{O}_3(\text{s})$.

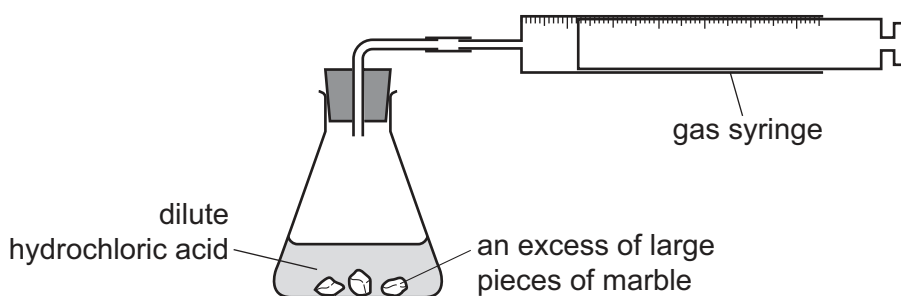
[M_r , $\text{FeSO}_4 = 152$; M_r , $\text{Fe}_2\text{O}_3 = 160$]

Calculate the percentage yield for this reaction.

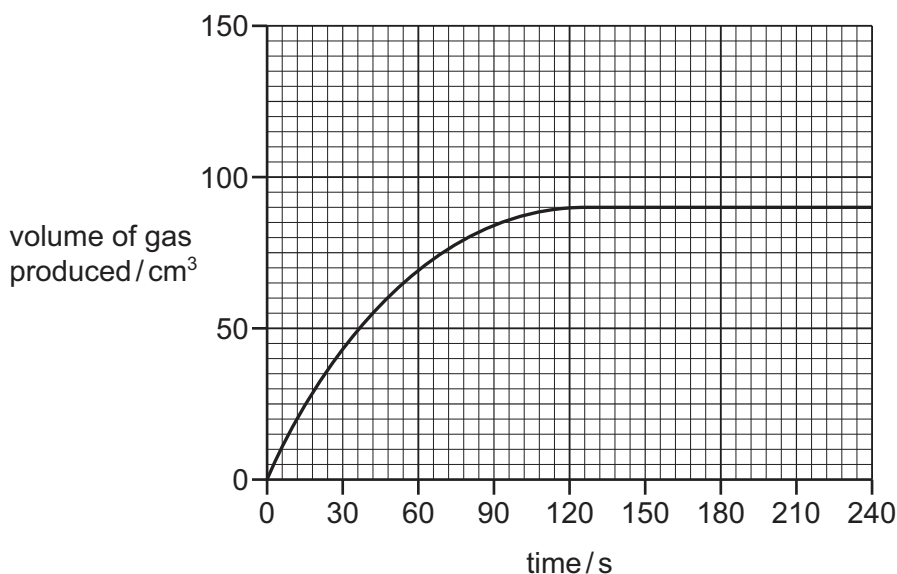
..... % [3]

[Total: 26]

- 4 A student investigated the progress of the reaction between dilute hydrochloric acid, HCl , and an excess of large pieces of marble, CaCO_3 , using the apparatus shown.



- (a) A graph of the volume of gas produced against time is shown.



- (i) How does the shape of the graph show that the rate of reaction decreased as the reaction progressed?

.....
 [1]

- (ii) Why did the rate of reaction decrease as the reaction progressed?

..... [1]

- (iii) After how many seconds did the reaction finish?

..... s [1]

- (b) The experiment was repeated using the same mass of smaller pieces of marble. All other conditions were kept the same.

Draw a graph **on the grid** to show the progress of the reaction using the smaller pieces of marble. [2]

- (c) The original experiment was repeated at a higher temperature. All other conditions were kept the same.

Describe and explain, in terms of collisions between particles, the effect of using a higher temperature on the time taken for the reaction to finish.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 10]

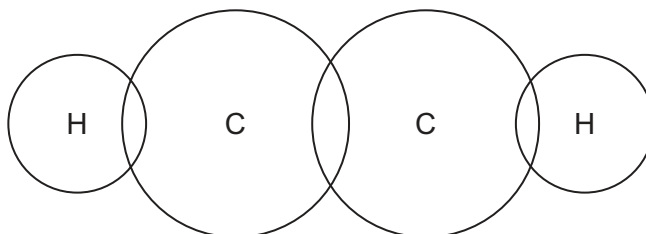
- 5 Alkynes are a homologous series of unsaturated hydrocarbons. All members contain a $C\equiv C$ triple bond.

(a) Complete the table showing information about the first **three** alkynes.

formula	C_2H_2	C_3H_4	
structure	$H-C\equiv C-H$	$H-C\equiv C-CH_3$	$H-C\equiv C-CH_2-CH_3$
name	ethyne		butyne

[2]

- (b) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of ethyne, $H-C\equiv C-H$. Show outer shell electrons only.



[2]

(c) Compounds in the same homologous series have the same general formula.

- (i) Give **two** other characteristics of members of a homologous series.

1

2

[2]

- (ii) Use the information in the table in (a) to deduce the general formula of alkynes.

..... [1]

(d) Alkynes are unsaturated.

Describe a test for unsaturation.

test

result

[2]

(e) (i) Name an oxidising agent which can be used to oxidise ethanol to ethanoic acid.

..... [2]

(ii) Draw the structure of ethanoic acid. Show all of the atoms and all of the bonds.

[1]

(f) Carboxylic acids can be converted into esters.

(i) The ester formed by reacting propanoic acid and methanol has the molecular formula $C_4H_8O_2$.

Name this ester and draw its structure. Show all of the atoms and all of the bonds.

name of the ester

structure of the ester

[2]

(ii) Name another ester with the molecular formula $C_4H_8O_2$.

..... [1]

(g) Polyesters are polymers.

(i) What type of polymerisation is used in the manufacture of polyesters?

..... [1]

(ii) Name a polyester.

..... [1]

[Total: 17]

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The Periodic Table of Elements

		Group																																			
I	II	III	IV	V	VI	VII	VIII																														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																				
Li lithium 7	Be beryllium 9	B boron 11	C carbon 12	Al aluminium 13	Si silicon 14	P phosphorus 15	S sulfur 16	Cl chlorine 17	Ar argon 18	K potassium 19	Ca calcium 20	Sc scandium 21	Ti titanium 22	V vanadium 23	Cr chromium 24	Mn manganese 25	Fe iron 26	Co cobalt 27	Ni nickel 28	Cu copper 29	Zn zinc 30	Ga gallium 31	Ge germanium 32	As arsenic 33	Se selenium 34	Br bromine 35	Kr krypton 36										
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57-71 lanthanoids	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86		
Rb rubidium 85	Sr strontium 88	Y yttrium 89	Zr zirconium 90	Nb niobium 91	Mo molybdenum 92	Tc technetium 93	Ru ruthenium 94	Rh rhodium 95	Pd palladium 96	Ag silver 97	Cd cadmium 98	In indium 99	Sn tin 100	Sb antimony 101	Te tellurium 102	I iodine 103	Xe xenon 104	Cs caesium 133	Ba barium 137	La lanthanum 139	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195	Au gold 197	Hg mercury 201	Tl thallium 204	Pb lead 207	Bi bismuth 209	Po polonium 210	At astatine 210	Rn radon 222		
87	88	89-103 actinoids	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138
Fr francium —	Ra radium —	Ac actinium —	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —	Rg roentgenium —	Cn copernicium —	Fl flerovium —	Lv livermorium —	Uu ununoctium —	Uub unubium —	Uut ununtrium —	Uuq ununquadium —	Uup ununpentium —	Uuq ununhexium —	Uus ununseptium —	Uuo ununoctium —	Uuh ununheptium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —		

1
H
hydrogen
1

Key
atomic number
atomic symbol
name
relative atomic mass

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 dm³ at room temperature and pressure (r.t.p.).