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CHEMISTRY

0620/43

Paper 4 Theory (Extended)

October/November 2019

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 syllabus is regulated for use in England, Wales and Northern Ireland as a Cambridge International Level 1/Level 2 Certificate.

This document consists of **14** printed pages and **2** blank pages.

- 1 (a) Atoms are made of smaller particles called electrons, neutrons and protons.

Complete the table.

particle	relative charge	relative mass
electron		$\frac{1}{1840}$
neutron		
proton	+1	

[2]

- (b) The table gives information about atoms and ions **A**, **B** and **C**.

Complete the table.

	number of electrons	number of neutrons	number of protons	symbol
A		14	13	${}_{13}^{27}\text{Al}$
B			12	${}_{12}^{25}\text{Mg}^{2+}$
C	10	10	9	

[6]

[Total: 8]

- 2 The table shows the melting points, boiling points and electrical conductivities of six substances **D, E, F, G, H** and **I**.

substance	melting point /°C	boiling point /°C	electrical conductivity when solid	electrical conductivity when liquid
D	1610	2230	non-conductor	non-conductor
E	801	1413	non-conductor	good conductor
F	-119	43	non-conductor	non-conductor
G	1535	2750	good conductor	good conductor
H	114	184	non-conductor	non-conductor
I	-210	-196	non-conductor	non-conductor

Choose substances from the table which match the following descriptions. Each substance may be used once, more than once or not at all.

(a) Which substance is a liquid at 25 °C? [1]

(b) Which substance is a gas at 25 °C? [1]

(c) Which **three** substances contain simple molecules?

..... [3]

(d) Which substance could be a metal? Give a reason for your answer.

substance

reason

[2]

(e) Which substance has a macromolecular structure? Give **two** reasons for your answer.

substance

reason 1

reason 2

[3]

(f) Which substance is an ionic solid? Give **one** reason for your answer.

substance

reason

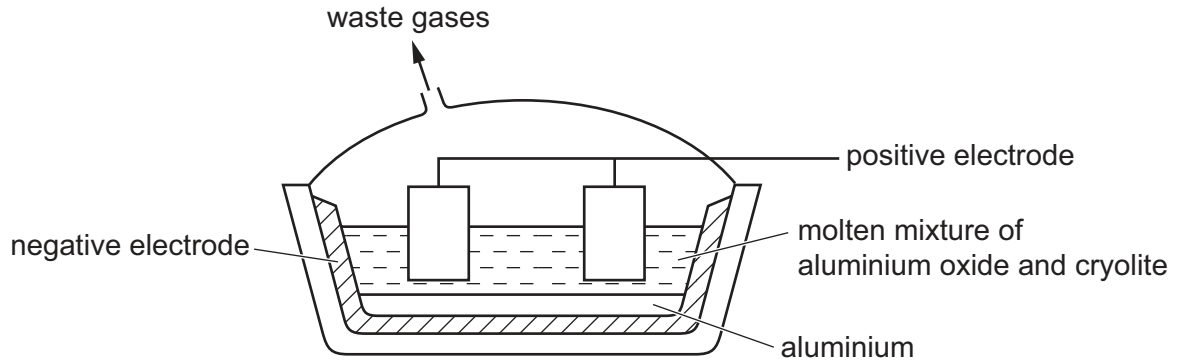
[2]

[Total: 12]

- 3 (a) Name the ore of aluminium which mainly consists of aluminium oxide.

..... [1]

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



- (i) Give **two** reasons why the electrolysis is done using a molten mixture of aluminium oxide and cryolite instead of molten aluminium oxide only.

1

2

[2]

- (ii) Write ionic half-equations for the reactions occurring at the electrodes.

positive electrode

negative electrode

[2]

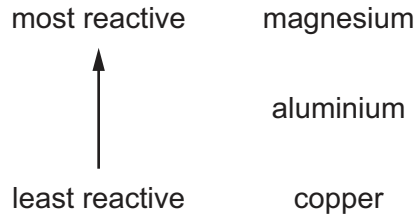
- (iii) The anodes are made of carbon and have to be replaced regularly.

Explain why the carbon anodes have to be replaced regularly.

.....

..... [2]

(c) The positions of some common metals in the reactivity series are shown.



(i) When magnesium is placed in aqueous copper(II) sulfate a displacement reaction occurs immediately.

Write an ionic equation for the reaction. Include state symbols.

..... [2]

(ii) State **two** observations you would make when magnesium is placed in aqueous copper(II) sulfate.

1

2

[2]

(iii) When aluminium foil is added to aqueous copper(II) sulfate no immediate reaction takes place.

Explain why.

..... [1]

(d) Aluminium powder reacts with iron(III) oxide to produce aluminium oxide and iron.

Write a chemical equation for this reaction.

..... [2]

[Total: 14]

4 This question is about phosphorus and compounds of phosphorus.

(a) A phosphorus molecule contains four phosphorus atoms **only**.

What is the formula of a phosphorus molecule?

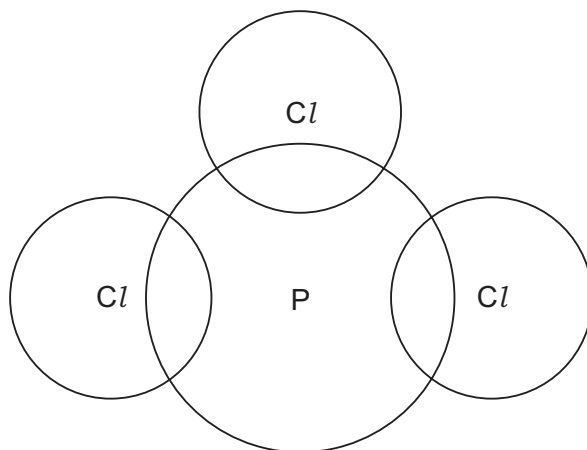
..... [1]

(b) Phosphorus reacts with chlorine gas to produce phosphorus(III) chloride, PCl_3 .

(i) Write a chemical equation for the reaction between phosphorus and chlorine to produce phosphorus(III) chloride, PCl_3 .

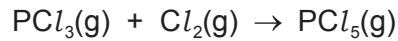
..... [2]

(ii) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of phosphorus(III) chloride, PCl_3 . Show outer shell electrons only.

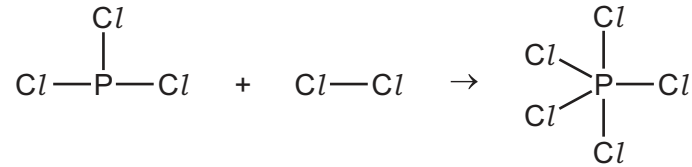


[2]

- (c) Gaseous phosphorus(III) chloride, PCl_3 , reacts with gaseous chlorine to form gaseous phosphorus(V) chloride, PCl_5 .



The chemical equation for this reaction can be represented as shown.



- (i) Use the bond energies in the table to calculate the energy change, in kJ/mol, of the reaction.

bond	bond energy in kJ/mol
P-Cl	326
Cl-Cl	243

- Energy needed to break bonds.

..... kJ

- Energy released when bonds are formed.

..... kJ

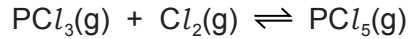
- Energy change of reaction.

energy change = kJ/mol
[3]

- (ii) Deduce whether the energy change for this reaction is exothermic or endothermic. Explain your answer.

.....
..... [1]

- (d) Under certain conditions the reaction reaches equilibrium.



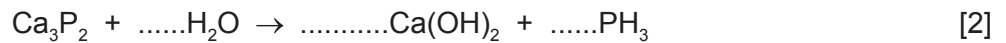
State and explain the effect, if any, on the **position of equilibrium** if the pressure is increased. All other conditions are unchanged.

.....

 [2]

- (e) Phosphine, PH_3 , is produced by the reaction between water and calcium phosphide, Ca_3P_2 .

Balance the chemical equation for this reaction.



- (f) The phosphonium ion, PH_4^+ , is similar to the ammonium ion.

(i) State the formula of the ammonium ion. [1]

(ii) Suggest the formula of phosphonium iodide. [1]

- (g) Calcium phosphate contains the phosphate ion, PO_4^{3-} .

What is the formula of calcium phosphate?

..... [1]

- (h) Phosphorus forms another compound with hydrogen with the following composition by mass: P, 93.94%; H, 6.06%.

(i) Calculate the empirical formula of the compound.

empirical formula = [2]

- (ii) The compound has a relative molecular mass of 66.

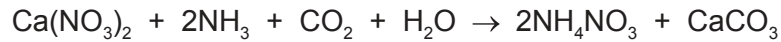
Deduce the molecular formula of the compound.

molecular formula = [1]

[Total: 19]

- 5 Nitrates such as ammonium nitrate are used as fertilisers.

The final stage in the production of ammonium nitrate is shown in the equation.



Calculate the maximum mass of ammonium nitrate that can be produced from 820g of calcium nitrate, $\text{Ca}(\text{NO}_3)_2$, using the following steps.

The relative formula mass, M_r , of calcium nitrate, $\text{Ca}(\text{NO}_3)_2$, = 164.

- Calculate the number of moles of $\text{Ca}(\text{NO}_3)_2$ in 820 g.

..... mol

- Deduce the number of moles of NH_4NO_3 produced.

..... mol

- Calculate the M_r of NH_4NO_3 .

M_r of NH_4NO_3 =

- Calculate the maximum mass of ammonium nitrate produced.

..... g
[4]

6 This question is about sulfuric acid and substances that can be made from sulfuric acid.

(a) Sulfuric acid is a strong acid.

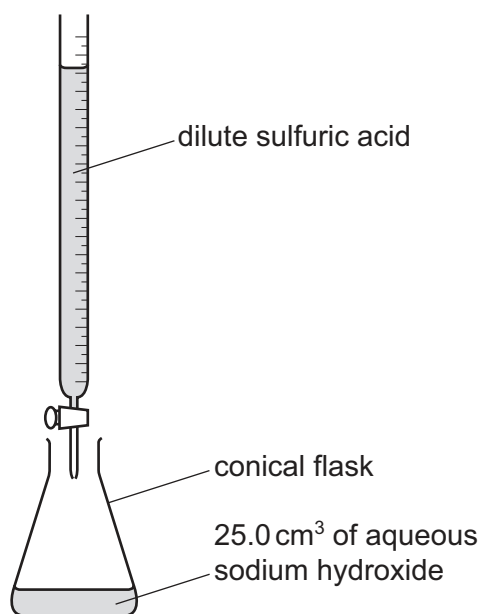
What is meant by the term *strong acid*?

strong

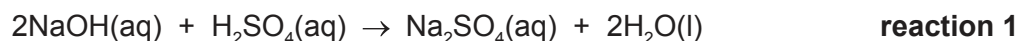
acid

[2]

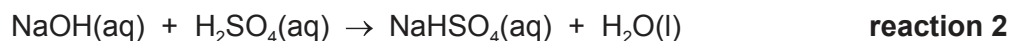
(b) Dilute sulfuric acid and aqueous sodium hydroxide are used to make aqueous sodium sulfate, $\text{Na}_2\text{SO}_4(\text{aq})$, or aqueous sodium hydrogen sulfate, $\text{NaHSO}_4(\text{aq})$. The method includes use of the following apparatus.



25.0 cm³ of aqueous sodium hydroxide of concentration 0.100 mol/dm³ was neutralised by 25.0 cm³ of dilute sulfuric acid of concentration 0.0500 mol/dm³. The equation for the reaction is shown. This is **reaction 1**.



The same technique and the same solutions can be used to make aqueous sodium hydrogen sulfate. The equation for the reaction is shown. This is **reaction 2**.



Complete the table to calculate the volume of dilute sulfuric acid that reacts with 25.0 cm³ of aqueous sodium hydroxide in **reaction 2**.

	volume of 0.0500 mol/dm ³ dilute sulfuric acid in cm ³	volume of 0.100 mol/dm ³ aqueous sodium hydroxide in cm ³
reaction 1	25.0	25.0
reaction 2		25.0

[1]

- (c) Aqueous sodium hydrogen sulfate, $\text{NaHSO}_4(\text{aq})$, contains the ions $\text{Na}^+(\text{aq})$, $\text{H}^+(\text{aq})$ and $\text{SO}_4^{2-}(\text{aq})$.

Describe what you would **see** if the following experiments were done.

- (i) A flame test was done on aqueous sodium hydrogen sulfate.

..... [1]

- (ii) Solid copper(II) oxide was added to aqueous sodium hydrogen sulfate and the mixture was warmed.

.....

..... [2]

- (d) A test can be done to show the presence of $\text{SO}_4^{2-}(\text{aq})$ by adding acidified aqueous barium chloride **or** acidified aqueous barium nitrate.

- (i) State the observation that would show that SO_4^{2-} is present.

..... [1]

- (ii) Write an ionic equation for the reaction that occurs if SO_4^{2-} is present. Include state symbols.

..... [2]

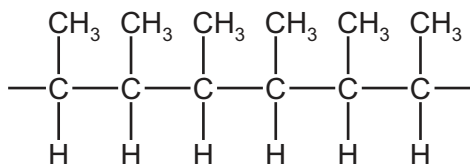
[Total: 9]

7 Addition polymerisation and condensation polymerisation are two types of polymerisation.

(a) Which functional group is present in all the monomers which are used to make addition polymers?

..... [1]

(b) Part of an addition polymer is shown.



(i) How many monomer units are needed to make the part of the addition polymer shown?

..... [1]

(ii) Draw the structure of the monomer that is used to make this addition polymer. Show all of the atoms and all of the bonds.

Name the monomer.

name [2]

(iii) State the empirical formula of:

the monomer

the polymer. [2]

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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 —		

Key

atomic number
atomic symbol
name
relative atomic mass

1
H
hydrogen
1

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.).