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CHEMISTRY

0620/41

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.

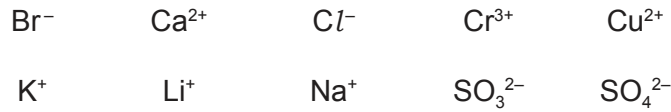
The number of marks is given in brackets [] at the end of each question or part question.

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 **16** printed pages.

1 This question is about ions and ionic compounds.

(a) Choose from the following list of ions to answer the questions.



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

State which ion:

- (i) gives a lilac colour in a flame test [1]
- (ii) forms a grey-green precipitate with aqueous ammonia [1]
- (iii) forms a white precipitate with aqueous sodium hydroxide [1]
- (iv) forms a cream precipitate with acidified aqueous silver nitrate [1]
- (v) forms a white precipitate with acidified aqueous barium nitrate. [1]

(b) Describe how to do a flame test on a sample of a salt.

.....

.....

.....

..... [2]

(c) Magnesium phosphate contains magnesium ions, Mg^{2+} , and phosphate ions, PO_4^{3-} .

Deduce the formula of magnesium phosphate.

..... [1]

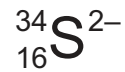
[Total: 8]

- 2 (a) Sulfur exists as a number of different isotopes.

What is meant by the term *isotopes*?

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

- (b) A sulfide ion has the symbol shown.



- (i) How many neutrons are contained in this sulfide ion?

..... [1]

- (ii) How is a sulfide ion, S^{2-} , formed from a sulfur atom?

..... [1]

- (iii) Which element forms an ion with a 2+ charge that has the same number of electrons as a S^{2-} ion?

..... [1]

(c) The manufacture of sulfuric acid by the Contact process occurs in four stages.

stage 1 Molten sulfur is burned in air to produce sulfur dioxide gas.

stage 2 Sulfur dioxide is reacted with oxygen to form sulfur trioxide.

stage 3 Sulfur trioxide is combined with concentrated sulfuric acid to form oleum, $\text{H}_2\text{S}_2\text{O}_7$.

stage 4 Oleum is added to water to form sulfuric acid.

(i) Complete the chemical equation for **stage 1** by adding the appropriate state symbols.



(ii) Name the catalyst used in **stage 2** and state the temperature used.

catalyst

temperature °C

[2]

(iii) Write chemical equations for the reactions in **stage 3** and **stage 4**.

stage 3

stage 4

[2]

(d) Sulfur dioxide is a toxic gas.

(i) State one **environmental** reason why sulfur dioxide should **not** be released into the atmosphere.

..... [1]

(ii) Describe the test for sulfur dioxide.

test

.....

observations

.....

[2]

- (e) Sulfur dioxide reacts with aqueous sodium sulfite to produce a compound with the following composition by mass: 29.1% Na, 40.5% S and 30.4% O.

Calculate the empirical formula of this compound.

empirical formula = [3]

[Total: 16]

3 This question is about metals and metal oxides.

(a) Most metals have a high melting point.

State **one** other physical property that all metals have.

..... [1]

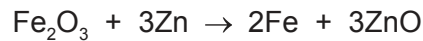
(b) Iron often rusts.

Name the **two** substances, other than iron, that must be present for iron to rust.

1

2 [1]

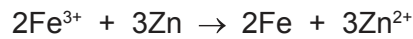
(c) Iron can be obtained by heating iron(III) oxide with zinc powder.



(i) What can be deduced about the reactivity of zinc from this reaction?

..... [1]

(ii) The ionic equation for this reaction is shown.



Identify the oxidising agent in this reaction. Explain your answer in terms of electron transfer.

oxidising agent

explanation

..... [2]

(d) Zinc oxide is amphoteric.

Describe **two** simple experiments to show that zinc oxide is amphoteric.
Name the reagents you would use and describe the observations you would make.

reagent 1

observation

reagent 2

observation

[3]

[Total: 8]

4 Insoluble salts can be made by precipitation reactions.

A student mixed solutions of some soluble salts.

The results the student obtained are shown in the table.

		second salt solution		
		$\text{Co}(\text{NO}_3)_2(\text{aq})$	$\text{AgNO}_3(\text{aq})$	$\text{Pb}(\text{NO}_3)_2(\text{aq})$
first salt solution	$\text{NaI}(\text{aq})$	no change	yellow precipitate	yellow precipitate
	$\text{Na}_2\text{CO}_3(\text{aq})$	purple precipitate	yellow precipitate	white precipitate
	$\text{Na}_2\text{SO}_4(\text{aq})$	no change	white precipitate	white precipitate

All sodium salts are soluble in water.

Use only results from the table to answer the following questions.

(a) Name:

(i) an insoluble cobalt salt [1]

(ii) an insoluble yellow lead salt. [1]

(b) Write the chemical equation for the reaction in which silver carbonate is formed.

..... [2]

(c) Write the ionic equation for the reaction in which lead(II) iodide is formed.

..... [2]

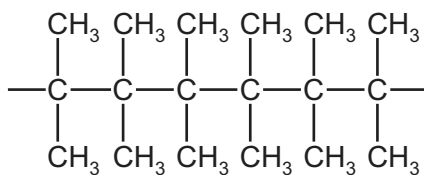
(d) Aqueous silver nitrate produces a yellow precipitate with both iodide ions and carbonate ions. When testing an unknown solution for iodide ions, the aqueous silver nitrate is acidified.

Explain why the aqueous silver nitrate is acidified.

.....
 [1]

[Total: 7]

- 5 (a) Part of the structure of synthetic polymer **A** is shown.



- (i) What type of synthetic polymer is **A**?

..... [1]

- (ii) Deduce the empirical formula of polymer **A**.

..... [1]

- (iii) Draw the structure of the monomer from which polymer **A** is made.

[2]

- (b) The formula C_4H_{10} represents two different structural isomers.

- (i) What is meant by the term *structural isomers*?

.....

 [2]

- (ii) Draw the structures of **two** structural isomers with the formula C_4H_{10} .
 Show all of the atoms and all of the bonds.

[2]

- (iii) All structural isomers of C_4H_{10} are flammable.

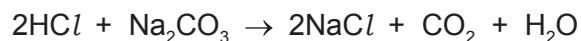
Write a chemical equation for the **incomplete** combustion of C_4H_{10} .

..... [2]

[Total: 10]

- 6 Dilute hydrochloric acid, $\text{HCl}(\text{aq})$, reacts with aqueous sodium carbonate, $\text{Na}_2\text{CO}_3(\text{aq})$.

The chemical equation for the reaction is shown.



- (a) A 25.0 cm^3 portion of $\text{Na}_2\text{CO}_3(\text{aq})$ was placed in a conical flask with a few drops of a suitable indicator. It was titrated against $\text{HCl}(\text{aq})$ of concentration 0.180 mol/dm^3 .

20.0 cm^3 of $\text{HCl}(\text{aq})$ was required to reach the end-point.

Calculate the concentration of the $\text{Na}_2\text{CO}_3(\text{aq})$, in mol/dm^3 , using the following steps.

- Calculate the number of moles of HCl used in the titration.

..... mol

- Calculate the number of moles of Na_2CO_3 contained in the 25.0 cm^3 portion of $\text{Na}_2\text{CO}_3(\text{aq})$.

..... mol

- Calculate the concentration of the $\text{Na}_2\text{CO}_3(\text{aq})$ in mol/dm^3 .

..... mol/dm^3
[3]

- (b) In another experiment, the volume of carbon dioxide, CO_2 , produced was 48.0 cm^3 , measured at room temperature and pressure.

How many moles of CO_2 is this?

moles of $\text{CO}_2 = \dots\dots\dots\text{ mol}$ [1]

- (c) A sample of concentrated hydrobromic acid, HBr(aq) , was electrolysed using platinum electrodes.

The concentration of the hydrobromic acid was 8.89 mol/dm^3 .

- (i) Calculate the concentration of the HBr(aq) in g/dm^3 .

concentration of HBr(aq) = g/dm^3 [1]

- (ii) Explain why concentrated HBr(aq) can conduct electricity.

.....

 [2]

- (iii) Magnesium is **not** a suitable material from which to make the electrodes.

Explain why.

.....
 [1]

- (iv) Predict the product formed at the anode when concentrated HBr(aq) is electrolysed.

..... [1]

- (v) Write the ionic half-equation for the reaction occurring at the cathode.

..... [2]

[Total: 11]

7 This question is about ethanol.

(a) Ethanol that is suitable for use as a fuel can be manufactured from sugars such as glucose, $C_6H_{12}O_6$, by a two-step process.

Describe how this can be done. In your answer, include:

- an equation for the reaction in which ethanol is formed
- the essential conditions for the reaction in which ethanol is formed
- the name of the process used to obtain ethanol that is pure enough to use as a fuel from the reaction mixture.

.....

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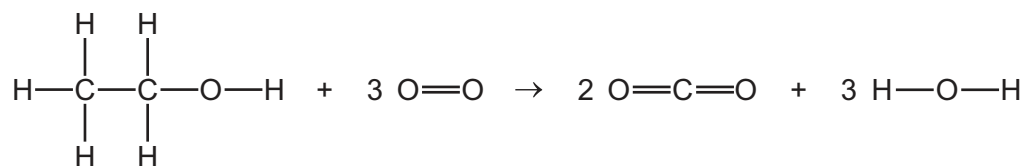
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.....

[5]

(b) The equation for the complete combustion of ethanol is shown.



Use the bond energies in the table to calculate the energy change, in kJ/mol, for the complete combustion of ethanol.

bond	bond energy in kJ/mol
C–C	347
C–H	413
C–O	358
C=O	805
O–H	464
O=O	498

- Energy needed to break bonds.

..... kJ

- Energy released when bonds are formed.

..... kJ

- Energy change for the complete combustion of ethanol.

energy change = kJ/mol
[3]

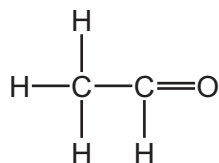
(c) Ethanol can be oxidised by hydrogen peroxide to form ethanal, CH_3CHO . A catalyst for this reaction is Fe^{3+} .

(i) What is meant by the term *catalyst*?

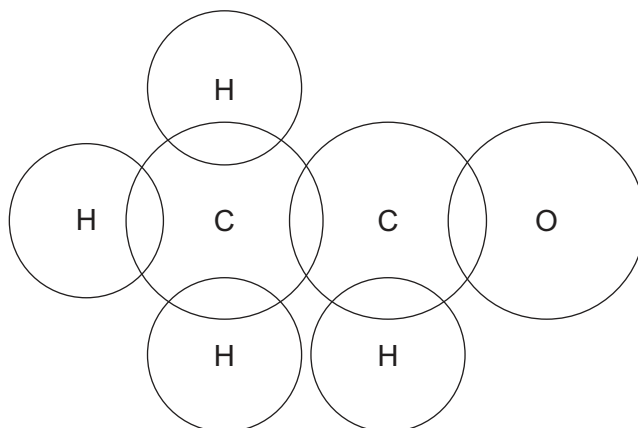
.....

 [2]

(ii) The structure of ethanal is shown.



Complete the dot-and-cross diagram to show the electron arrangement in a molecule of ethanal. Show outer shell electrons only.



[3]

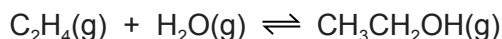
(iii) The table gives the boiling points of ethanal and ethanol.

substance	boiling point/ $^{\circ}\text{C}$
ethanal	20
ethanol	78

In terms of attractive forces between particles, suggest why ethanal has a lower boiling point than ethanol.

.....
 [1]

- (d) Ethene gas reacts with steam to form gaseous ethanol.



The reaction can reach a position of equilibrium. The forward reaction is exothermic.

- (i) State and explain the effect of increasing the pressure on the **position of equilibrium**.
All other conditions are unchanged.

.....

 [2]

- (ii) Increasing the pressure of a gas increases its concentration.

State and explain the effect of increasing the pressure on the **rate** of the reaction.
All other conditions are unchanged.

.....

 [2]

- (iii) State and explain the effect of increasing the temperature on the **position of equilibrium**.
All other conditions are unchanged.

.....

 [2]

[Total: 20]

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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 101	Rh rhodium 103	Pd palladium 106	Ag silver 108	Cd cadmium 112	In indium 115	Sn tin 119	Sb antimony 122	Te tellurium 128	I iodine 127	Xe xenon 131	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
Fr francium	Ra radium	Ac actinium	Rf rutherfordium	Db dubnium	Sg seaborgium	Bh bohrium	Hs hassium	Mt meitnerium	Ds darmstadtium	Rg roentgenium	Cn copernicium	Nh nihonium	Fl flerovium	Mc moscovium	Lv livermorium	Ts tennessine	Og oganeson	Uu unbinilium	Uub unbibium	Uut untrium	Uuq unquadium	Uuq unquadium	Uup unpentium	Uuq unquadium	Uuq unquadium	Uuq unquadium	Uuq unquadium	Uuq unquadium	Uuq unquadium	Uuq unquadium	Uuq unquadium	Uuq unquadium	Uuq unquadium	Uuq unquadium	Uuq unquadium

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.).