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CHEMISTRY

0620/41

Paper 4 Theory (Extended)

May/June 2020

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [].
- The Periodic Table is printed in the question paper.

This document has **12** pages. Blank pages are indicated.

1 This question is about elements **X**, **Y** and **Z**.

(a) An atom of element **X** is represented as ${}_{16}^{34}\text{X}$.

(i) Name the different types of particles found in the nucleus of this atom of **X**.

.....
 [2]

(ii) What is the term for the total number of particles in the nucleus of an atom?

..... [1]

(iii) What is the total number of particles in the nucleus of an atom of ${}_{16}^{34}\text{X}$?

..... [1]

(iv) What is the electronic structure of the ion X^{2-} ?

..... [1]

(v) Suggest the formula of the compound formed between aluminium and **X**.

..... [1]

(b) (i) What term is used to describe atoms of the same element with different numbers of particles in the nucleus?

..... [1]

(ii) Identify the atom against which the relative masses of all other atoms are compared.

..... [1]

(iii) What is the name of the amount of any substance that contains 6.02×10^{23} particles?

..... [1]

(iv) The constant 6.02×10^{23} has a name.

What is the name of this constant?

..... [1]

- (c) Part of the definition of relative atomic mass is ‘the average mass of naturally occurring atoms of an element’.

Some relative atomic masses are not whole numbers.

Element **Y** has only two different types of atom, ^{69}Y and ^{71}Y .

The ratio of atoms present in element **Y** is shown.

$$^{69}\text{Y} : ^{71}\text{Y} = 3 : 2$$

- Calculate the relative atomic mass of element **Y** to **one decimal place**.

relative atomic mass =

- Identify element **Y**.

..... [3]

- (d) Element **Z** is in Period 3 and Group V.

- (i) Identify element **Z**.

..... [1]

- (ii) Explain in terms of electron transfer why **Z** behaves chemically as a non-metal.

..... [2]

[Total: 16]

2 Magnesium is a metal.

(a) Name and describe the bonding in magnesium.

name

description of bonding

.....

.....

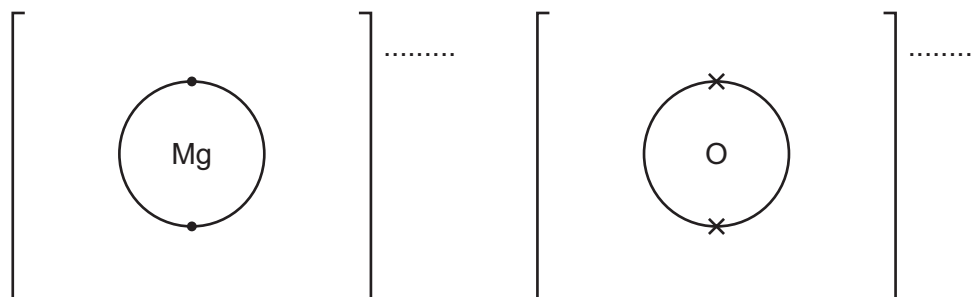
[4]

(b) Magnesium oxide, MgO, is formed when magnesium burns in oxygen.

(i) Complete the dot-and-cross diagram to show the electron arrangement of the ions in magnesium oxide.

The inner shells have been drawn.

Give the charges on the ions.



[3]

(ii) Write the chemical equation for the reaction that occurs when magnesium burns in oxygen.

..... [2]

(c) Magnesium oxide also forms when magnesium nitrate, $\text{Mg}(\text{NO}_3)_2$, is heated strongly. This is an endothermic reaction.

(i) Write the chemical equation for this reaction.

..... [2]

(ii) What type of reaction is this?

..... [1]

(iii) Name **two** other compounds of magnesium that form magnesium oxide when heated.

.....

..... [2]

[Total: 14]

3 Sulfur dioxide, SO₂, is used in the manufacture of sulfuric acid.

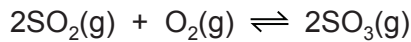
(a) In the first stage of the process, sulfur dioxide is obtained from sulfur-containing ores.

Name **one** of these ores.

..... [1]

(b) The next stage of the process is a reaction which can reach equilibrium.

The equation for this stage is shown.



(i) Describe **two** features of an equilibrium.

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

(ii) Name the catalyst used in this stage.

..... [1]

(iii) Why is a catalyst used?

..... [1]

(iv) Explain, in terms of particles, why a high temperature increases the rate of this reaction.

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

(v) In this stage, only a moderate temperature of 450 °C is used.

What does this suggest about the forward reaction?

..... [1]

(vi) Calculate the percentage by mass of sulfur in sulfur trioxide, SO₃.

percentage = [2]

- (c) Concentrated sulfuric acid is a dehydrating agent which can chemically remove water from substances.

Both hydrated copper(II) sulfate crystals and sucrose (a sugar), $C_{12}H_{22}O_{11}$, can be completely dehydrated by concentrated sulfuric acid.

Name the solid product formed in each case.

hydrated copper(II) sulfate crystals

sucrose

[2]

- (d) When propan-1-ol is heated with concentrated sulfuric acid as a catalyst an unsaturated hydrocarbon of relative molecular mass 42 is formed and one other product.

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

..... [1]

- (ii) Write the chemical equation for this reaction.

..... [2]

- (iii) Name the unsaturated hydrocarbon formed.

..... [1]

[Total: 17]

4 This question is about reactions of bases and acids.

(a) Ammonia is a gas at room temperature.

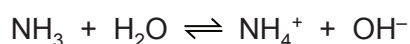
What is the test for ammonia gas? Describe the positive result of this test.

test

result

[2]

(b) Ammonia reacts with water to form ions.



(i) How does this equation show that ammonia, NH_3 , behaves as a base?

..... [1]

(ii) Aqueous ammonia is described as a weak base.

Suggest the pH of aqueous ammonia.

pH = [1]

(iii) Describe what is seen when aqueous ammonia is added to aqueous copper(II) sulfate, until no further change is seen.

.....

.....

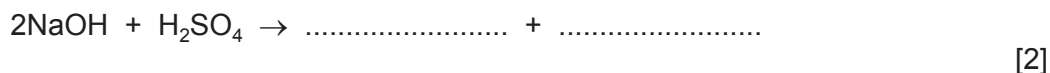
..... [3]

(c) Aqueous sodium hydroxide, NaOH(aq), is a strong alkali that reacts with dilute sulfuric acid exothermically.

(i) What type of reaction is this?

..... [1]

(ii) Complete the equation for the reaction between aqueous sodium hydroxide and dilute sulfuric acid.



(d) A student wanted to find the concentration of some dilute sulfuric acid by titration. The student found that 25.0 cm³ of 0.0400 mol/dm³ NaOH(aq) reacted exactly with 20.0 cm³ of H₂SO₄(aq).

(i) Name a suitable indicator to use in this titration.

..... [1]

(ii) Calculate the concentration of the H₂SO₄(aq) in mol/dm³ using the following steps.

- Calculate the number of moles of NaOH in 25.0 cm³.

moles =

- Deduce the number of moles of H₂SO₄ that reacted with the 25.0 cm³ of NaOH(aq).

moles =

- Calculate the concentration of H₂SO₄(aq) in mol/dm³.

concentration = mol/dm³
[3]

(iii) Calculate the concentration of the 0.0400 mol/dm³ NaOH(aq) in g/dm³.

concentration = g/dm³ [2]

[Total: 16]

5 Ethanol is manufactured by two different processes.

(a) For each process, name the organic reactant and state the type of reaction.

organic reactant type of reaction

organic reactant type of reaction

[4]

(b) Alcohols can be oxidised to form carboxylic acids.

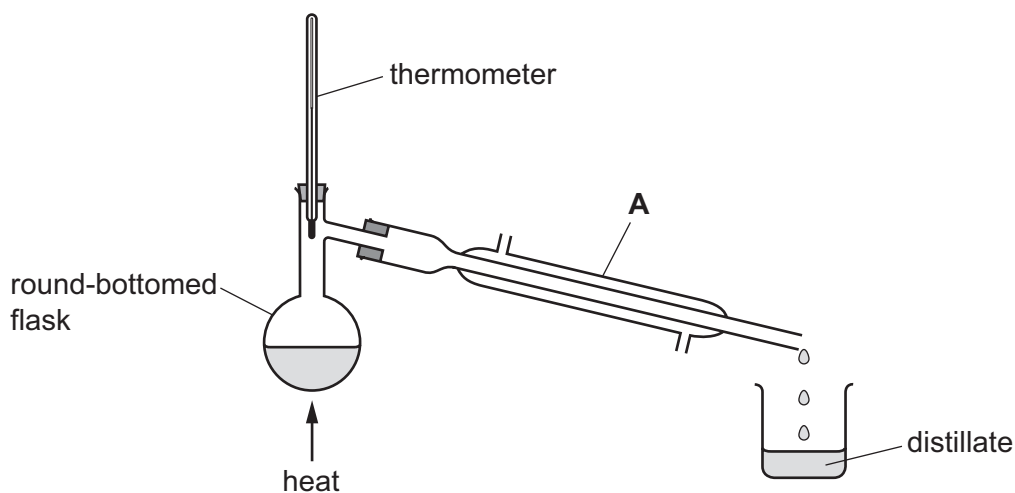
Name a suitable oxidising agent for this reaction.

..... [1]

(c) Alcohols can be partially oxidised to form aldehydes.

Aldehydes are a homologous series of organic compounds.

Partial oxidation is achieved by reacting an alcohol with the oxidising agent in distillation apparatus as shown.



(i) Name apparatus **A**.

..... [1]

(ii) On the diagram, use **one** arrow to show where water enters apparatus **A**.

[1]

(d) The table shows some information about aldehydes.

(i) Complete the table.

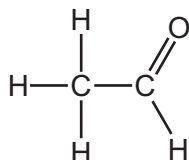
name	ethanal	propanal	butanal
molecular formula	CH ₂ O	C ₂ H ₄ O	C ₃ H ₆ O

[2]

(ii) Deduce the general formula of aldehydes.

..... [1]

(e) The structural formula of ethanal is shown.

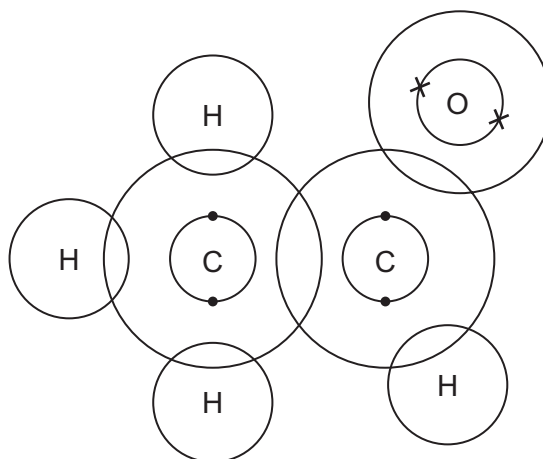


The C=O group in aldehydes is at the end of the carbon chain.
This is a reactive part of the molecule.

(i) What is the name given to the reactive part of any organic molecule?

..... [1]

(ii) Complete the dot-and-cross diagram to show the electron arrangement of a molecule of ethanal. Inner shells have been drawn.



[3]

(f) Propanone belongs to a homologous series called ketones. Ketones have the same C=O group as aldehydes but the C=O group is not at the end of the carbon chain. Propanone has the same molecular formula as propanal, C_3H_6O .

(i) What term is used to describe molecules with different structures but with the same molecular formula?

..... [1]

(ii) Suggest the structure of propanone, C_3H_6O . Show all of the atoms and all of the bonds.

[2]

[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
H hydrogen 1	He helium 4	B boron 11	C carbon 12	N nitrogen 14	O oxygen 16	F fluorine 19	Ne neon 20		
11	12	13	14	15	16	17	18		
Na sodium 23	Mg magnesium 24	Al aluminium 27	Si silicon 28	P phosphorus 31	S sulfur 32	Cl chlorine 35.5	Ar argon 40		
19	20	21	22	23	24	25	26	27	28
K potassium 39	Ca calcium 40	Sc scandium 45	Ti titanium 48	V vanadium 51	Cr chromium 52	Mn manganese 55	Fe iron 56	Co cobalt 59	Ni nickel 59
37	38	39	40	41	42	43	44	45	46
Rb rubidium 85	Sr strontium 88	Y yttrium 89	Zr zirconium 91	Nb niobium 93	Mo molybdenum 96	Tc technetium —	Ru ruthenium 101	Rh rhodium 103	Pd palladium 106
55	56	57–71	72	73	74	75	76	77	78
Cs caesium 133	Ba barium 137	lanthanoids	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195
87	88	89–103	104	105	106	107	108	109	110
Fr francium —	Ra radium —	actinoids	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —
81	82	83	84	85	86	87	88	89	90
Tl thallium 204	Pb lead 207	Bi bismuth 209	Po polonium —	At astatine —	Rn radon —	Cn copernicium —	Hg mercury 201	Au gold 197	Pt platinum 195
113	114	115	116	117	118	119	120	121	122
In indium 115	Sn tin 119	Sb antimony 122	Te tellurium 128	I iodine 127	Xe xenon 131	Pb lead 207	Hg mercury 201	Au gold 197	Pt platinum 195
151	152	153	154	155	156	157	158	159	160
Fl flerovium —	Lv livermorium —	Cn copernicium —	Nh nihonium —	Mc moscovium —	Lr lawrencium —	Ds darmstadtium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —
111	112	113	114	115	116	117	118	119	120
Rg roentgenium —	Cn copernicium —	Fl flerovium —	Mc moscovium —	Lr lawrencium —	Uu unbinilium —	Uut ununtrium —	Uuq ununquadium —	Uup ununpentium —	Uuq ununquadium —

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.).