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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.

[Turn over

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

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

Question no. 1

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

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

The nucleus of any atom contains **protons** and **neutrons**. **Protons** are positively charged particles, and **neutrons** are neutral particles. These two particles together make up the nucleus.

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

The total number of particles in the nucleus (that is, the total number of **protons + neutrons**) is called the **nucleon number** (also known as the **mass number**).

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

In the notation $^{34}_{16}X$, the top number **34** is the **nucleon number**, which equals the total number of particles in the nucleus (protons + neutrons).
So, the total number of particles in the nucleus is **34**.

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

The atomic number of X is **16**, so a neutral atom of X has **16 electrons**.
The ion X^{2-} has gained **2 extra electrons**, so it has **18 electrons** in total.

Filling shells: **2 in the first shell**, **8 in the second**, and the remaining **8 in the third**.
So the electronic structure is **2 : 8 : 8**.

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

Aluminium forms **Al³⁺** ions, while X forms **X²⁻** ions (as shown in part (iv)).

To make a neutral compound, the total positive charge must equal the total negative charge.
The lowest common multiple of 3 and 2 is **6**, so we need **2 aluminium ions** (total charge +6) and **3 X ions** (total charge −6).

Therefore, the formula is **Al₂X₃**.

(b)

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

Atoms of the same element (same number of protons) but with different numbers of neutrons are called **isotopes**.

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

Relative atomic masses are compared with **carbon-12**, written as **¹²C**. This isotope is used as the standard reference.

(iii) What is the name of the amount of any substance that contains 6.02 × 10²³ particles?

An amount of substance that contains **6.02 × 10²³ particles** is called **one mole** (or simply **a mole**).

(iv) The constant 6.02 × 10²³ has a name. What is the name of this constant?

The constant **6.02 × 10²³** is called the **Avogadro constant**.

(c) Element Y has only two different types of atom, ⁶⁹Y and ⁷¹Y, and ⁶⁹Y : ⁷¹Y = 3 : 2

Calculate the relative atomic mass of element Y to one decimal place, and identify element Y.

Because the relative atomic mass is the **average mass of naturally occurring atoms**, we calculate a weighted mean using the ratio 3 : 2.

This means that out of every 5 atoms, **3 are mass 69** and **2 are mass 71**.

So the total mass for 5 atoms is:

- mass from ⁶⁹Y atoms = **3 × 69 = 207**
- mass from ⁷¹Y atoms = **2 × 71 = 142**
- total mass = **207 + 142 = 349**

Average (relative atomic mass) = total mass ÷ total number of atoms
= **349 ÷ 5 = 69.8**

So the relative atomic mass of Y (to one decimal place) is **69.8**.

An element with a relative atomic mass close to **69.7–69.8** is **gallium**, symbol **Ga**. Therefore, **Y is gallium (Ga)**.

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

(i) Identify element Z.

In **Period 3**, the elements include sodium, magnesium, aluminium, silicon, **phosphorus**, sulfur, chlorine, argon.
Group V (Group 15) in Period 3 corresponds to **phosphorus**.

So **Z is phosphorus (P)**.

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

Phosphorus is a **non-metal** because, in reactions, it tends to **gain electrons rather than lose them**.
It has **five outer-shell electrons**, so it is energetically easier for it to **gain three electrons** to achieve a full outer shell (forming P^{3-}) than to lose five electrons.

So, Z behaves as a non-metal because it **gains electrons (specifically three when forming an ion)**.

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, $Mg(NO_3)_2$, 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]

Question no. 2

(a) Name and describe the bonding in magnesium

Name: Metallic bonding.

Description of bonding: In solid magnesium, each magnesium atom contributes its outer electrons to a **delocalised "sea of electrons"**. The magnesium atoms become **positive metal ions (Mg^{2+} ions)** arranged in a regular lattice. The **strong electrostatic attraction** between the **positive ions** and the **delocalised electrons** holds the metal together and is what we call **metallic bonding**.

(b) Magnesium oxide, MgO

(i) Dot-and-cross diagram + charges (ions in MgO)

Magnesium loses two electrons to form **Mg^{2+}**, and oxygen gains two electrons to form **O^{2-}**. So:

- **Mg^{2+}** has a full outer shell shown as **8 dots** (as required by the mark scheme for this diagram style).
- **O^{2-}** has a full outer shell shown as **6 crosses (its own)** and **2 dots (from Mg)**.
- Charges are **2+** on Mg and **2−** on O.

Key: dots = electrons from Mg, crosses = electrons from O
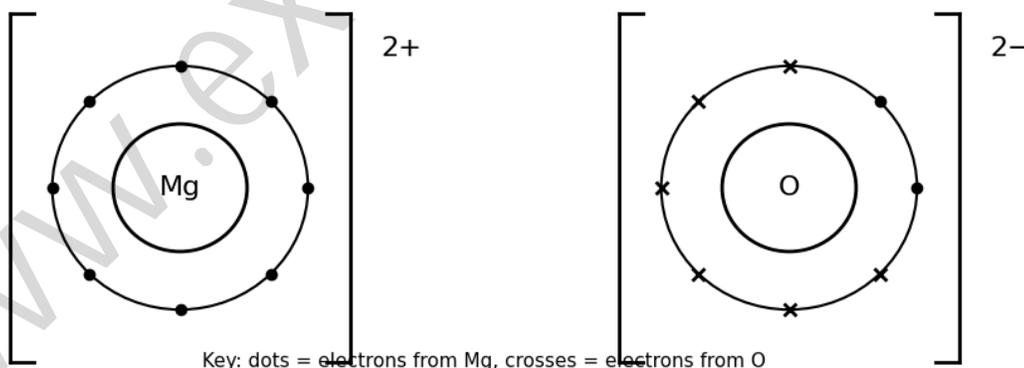
(ii) Chemical equation for magnesium burning in oxygen

When magnesium burns in oxygen, it forms magnesium oxide. The balanced equation is:

2Mg + O₂ → 2MgO
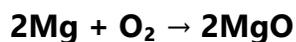
(c) Heating magnesium nitrate, Mg(NO₃)₂ (endothermic)

(i) Chemical equation

On strong heating, magnesium nitrate breaks down to magnesium oxide, nitrogen dioxide, and oxygen. The balanced equation is:

2Mg(NO₃)₂ → 2MgO + 4NO₂ + O₂

(ii) Type of reaction

This is **thermal decomposition**, because **one compound breaks down into simpler substances when heated**.

(iii) Two other magnesium compounds that form MgO when heated

Two correct examples are:

magnesium carbonate and **magnesium hydroxide**.

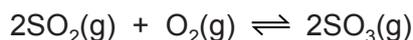**3** Sulfur dioxide, SO_2, is used in the manufacture of sulfuric acid.

(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.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(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, SO_3.

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]

Question no. 3

(a) Name one sulfur-containing ore used to produce sulfur dioxide

One suitable sulfur-containing ore is **zinc blende (zinc sulfide, ZnS)**.

(b) $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

(i) Describe two features of an equilibrium

In this reaction, **equilibrium** means the process is **reversible** (the forward and reverse reactions can both occur). At equilibrium, the system is in a **dynamic balance**, where the **rate of the forward reaction equals the rate of the reverse reaction**, so the amounts (concentrations) of SO_2, O_2 and SO_3 stay **constant** even though reactions are still happening.

(ii) Name the catalyst used in this stage

The catalyst used is **vanadium(V) oxide, V_2O_5**.

(iii) Why is a catalyst used?

A catalyst is used because it **increases the rate of reaction** (so equilibrium is reached faster and production is quicker).

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

At a higher temperature, gas particles (SO_2 and O_2 molecules) have **more kinetic energy** and move faster. This leads to **more frequent collisions per second**, increasing the chance of reaction occurring. Also, because the particles have more energy, a **larger proportion of collisions have energy greater than the activation energy**, so **more collisions are successful**, which increases the reaction rate.

(v) Only a moderate temperature of 450 °C is used. What does this suggest about the forward reaction?

Using only a moderate temperature suggests the forward reaction is **exothermic**. (If it releases heat, very high temperatures would reduce the equilibrium yield of SO_3, so industry uses a compromise temperature.)

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

Relative atomic masses: S = 32, O = 16.

Mr of SO3 = 32 + (3 × 16) = 32 + 48 = **80**.

Percentage of sulfur by mass
= (mass of S ÷ Mr of SO3) × 100
= (32 ÷ 80) × 100
= 0.4 × 100
= **40%**.

So, the percentage by mass of sulfur in SO3 is **40%**.

(c) Dehydration by concentrated sulfuric acid: name the solid product formed

Concentrated sulfuric acid removes water chemically.

- Hydrated copper(II) sulfate crystals (CuSO4·5H2O) lose water to form **anhydrous copper(II) sulfate (CuSO4)** (a white solid).
- Sucrose (C12H22O11) is dehydrated, leaving **carbon** (a black solid "char").

(d) Dehydration of propan-1-ol with concentrated sulfuric acid

(i) What is meant by the term unsaturated?

An **unsaturated** hydrocarbon is one in which **not all carbon–carbon bonds are single** — it contains at least one **C=C double bond** (or a C≡C bond).

(ii) Write the chemical equation for this reaction

When propan-1-ol is dehydrated, it forms an alkene and water:

C3H7OH → C3H6 + H2O

(iii) Name the unsaturated hydrocarbon formed

C3H6 is **propene**.

4 This question is about reactions of bases and acids.

(a) Ammonia is a gas at room temperature.

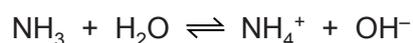What is the test for ammonia gas? Describe the positive result of this test.

test ....

result ....
[2]

(b) Ammonia reacts with water to form ions.

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

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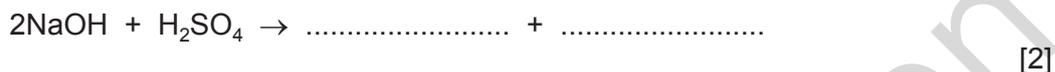
(c) Aqueous sodium hydroxide, NaOH(aq), is a strong alkali that reacts with dilute sulfuric acid exothermically.

(i) What type of reaction is this?

.... [1]

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

$2NaOH + H_2SO_4 \rightarrow$ .... + ...

[2]

(d) A student wanted to find the concentration of some dilute sulfuric acid by titration. The student found that $25.0\,cm^3$ of $0.0400\,mol/dm^3$ NaOH(aq) reacted exactly with $20.0\,cm^3$ of H_2SO_4(aq).

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

.... [1]

(ii) Calculate the concentration of the H_2SO_4(aq) in mol/dm^3 using the following steps.

● Calculate the number of moles of NaOH in $25.0\,cm^3$.

moles = ...

● Deduce the number of moles of H_2SO_4 that reacted with the $25.0\,cm^3$ of NaOH(aq).

moles = ...

● Calculate the concentration of H_2SO_4(aq) in mol/dm^3.

concentration = ... mol/dm^3

[3]

(iii) Calculate the concentration of the $0.0400\,mol/dm^3$ NaOH(aq) in g/dm^3.

concentration = ... g/dm^3 [2]
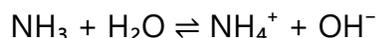
[Total: 16]

Question no. 4

(a) Test for ammonia gas, NH_3

Test: Hold **damp red litmus paper** in the gas.

Positive result: The litmus paper **turns blue** because ammonia is alkaline in moist conditions (it forms hydroxide ions in the water on the paper).

(b) Ammonia reacting with water to form ions

$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

(i) How this shows ammonia behaves as a base

This equation shows ammonia behaves as a base because **NH_3 accepts a proton (H^+)** from water to form **NH_4^+**. A **proton acceptor** is a Brønsted–Lowry base.

(ii) Suggested pH of aqueous ammonia

Aqueous ammonia is a **weak base**, so its pH is **above 7 but not extremely high**. A suitable value is around **pH 10** (any sensible value **up to about 11** is acceptable).

(iii) What is seen when aqueous ammonia is added to aqueous copper(II) sulfate (until no further change)

At first, a **light blue precipitate** forms (copper(II) hydroxide).
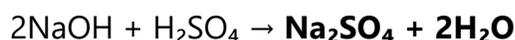On adding **excess ammonia**, the **precipitate dissolves**, forming a **deep blue solution**.
After that, **no further visible change** occurs and the **deep blue solution remains**.

(c) Reaction of NaOH(aq) with dilute H_2SO_4(aq)

(i) What type of reaction is this?

This is a **neutralisation reaction** (acid + alkali → salt + water), and it is exothermic.

(ii) Complete the equation

$2NaOH + H_2SO_4 \rightarrow$ **$Na_2SO_4 + 2H_2O$**

(d) Titration to find concentration of dilute sulfuric acid

Given: 25.0 cm³ of 0.0400 mol/dm³ NaOH reacts exactly with 20.0 cm³ H_2SO_4.

(i) Suitable indicator

A suitable indicator is **methyl orange** (strong acid–strong base titration gives a sharp end-point).

(ii) Calculate the concentration of H_2SO_4 in mol/dm³

First find moles of NaOH used:
Volume of NaOH = 25.0 cm³ = **0.0250 dm³**
Moles NaOH = concentration × volume
Moles NaOH = **0.0400 × 0.0250 = 0.00100 mol**

Now use the balanced equation:
2NaOH : 1H_2SO_4
So moles of H_2SO_4 = **0.00100 ÷ 2 = 0.000500 mol**
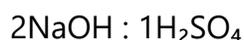
This amount of H_2SO_4 is in 20.0 cm³ = **0.0200 dm³**.
Concentration of H_2SO_4 = moles ÷ volume
Concentration = **0.000500 ÷ 0.0200 = 0.0250 mol/dm³**
So **[H_2SO_4] = 0.025 mol/dm³**.

(iii) Convert 0.0400 mol/dm³ NaOH to g/dm³

Molar mass of NaOH = 23 + 16 + 1 = **40 g/mol**
Mass concentration = molar concentration × molar mass
= **0.0400 × 40 = 1.60 g/dm³**

So the concentration is **1.6 g/dm³**.

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.
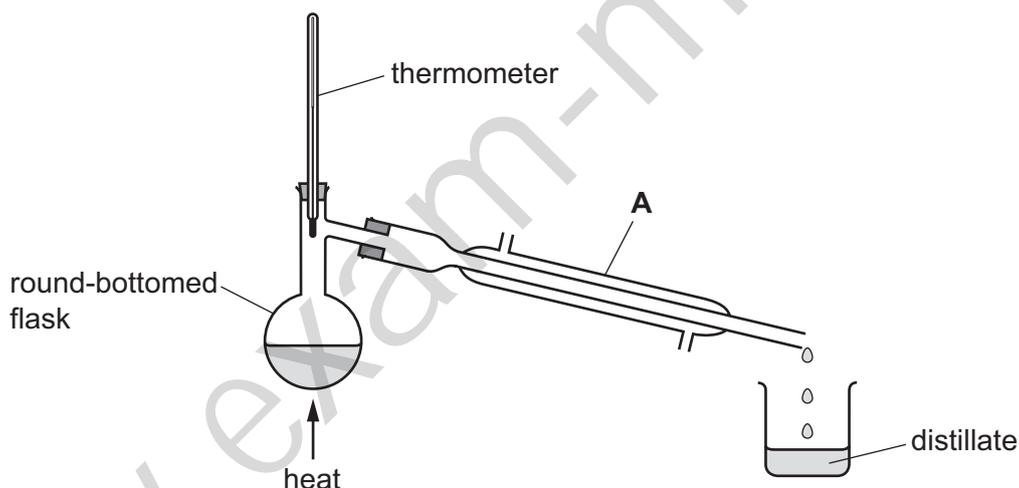
(i) Name apparatus **A**.

.... [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_2O	C_2H_4O	C_3H_6O	....

[2]

(ii) Deduce the general formula of aldehydes.

.... [1]

(e) The structural formula of ethanal is shown.
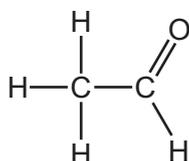
The C=O group in aldehydes is at the end of the carbon chain.
This is a reactive part of the molecule.

(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.
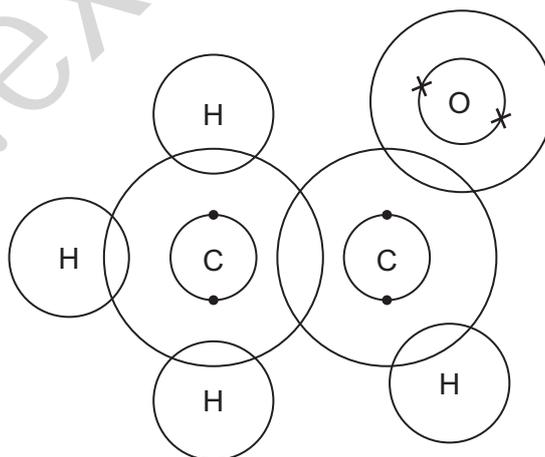
[3]

(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]

Question no. 5

(a) Two processes for making ethanol (name the organic reactant + type of reaction)

Ethanol can be made in two main industrial ways:

- **Organic reactant: sugars (e.g. glucose) → type of reaction: fermentation** (by yeast, producing ethanol and carbon dioxide).
- **Organic reactant: ethene → type of reaction: hydration** (addition of steam/water across the C=C double bond to form ethanol).

(b) Oxidising alcohols to carboxylic acids (oxidising agent)

A suitable oxidising agent is **acidified potassium manganate(VII)** (potassium permanganate), i.e. **KMnO4 / H+**.

(c) Partial oxidation to form aldehydes (distillation set-up)

(i) Name apparatus A

Apparatus A is a **(Liebig) condenser**.

(ii) Where water enters apparatus A

Water should enter at the **lower inlet** (so the condenser jacket stays completely filled and gives the best cooling).

Here is the diagram with the correct water-in point marked:

(d) Aldehydes table + general formula

(i) Complete the table

The aldehyde with molecular formula **CH2O** is **methanal**.

Butanal has one more carbon than propanal, so its molecular formula is **C4H8O**.

So the completed entries are: **methanal** and **C4H8O**.

(ii) General formula of aldehydes

From CH2O, C2H4O, C3H6O, C4H8O, you can see hydrogen increases by 2 each time carbon increases by 1, so the general formula is:

CnH2nO

(e) Ethanal structure questions

(i) Name of the reactive part of an organic molecule

The reactive part is called the **functional group**.

(ii) Dot-and-cross diagram for ethanal (completed)

Ethanal is **CH3CHO**. It must show:

- **4 C–H bonds** and **1 C–C bond** (single bonds),
- a **C=O double bond**,
- and **two lone pairs on oxygen**.

Here is a completed dot-and-cross diagram (with a key):

(f) Propanone vs propanal

(i) Term for same molecular formula but different structures

They are **(structural) isomers**.

(ii) Structure of propanone, C3H6O (show all atoms and bonds)

Propanone is a ketone, so the **C=O must be on the second (middle) carbon** in a 3-carbon chain: **CH3–CO–CH3**.

The Periodic Table of Elements

Group

I	II												III	IV	V	VI	VII	VIII
							1 H hydrogen 1											2 He helium 4
3 Li lithium 7	4 Be beryllium 9												5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24												13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65		31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112		49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201		81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –			114 Fl flerovium –		116 Lv livermorium –		

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 $24\,dm^3$ at room temperature and pressure (r.t.p.).