BENENDEN

SIXTH FORM ENTRANCE 2023

CHEMISTRY

1 hour 30 minutes

Name:	……..……
School:	……
Date:	……..…

Instructions to Candidates:

- *Fill in the boxes above with your name, school and the date*
- *Use black ink or ball point pen. If you change your mind about an answer please put a line through it and then write your new answer (no Tipex or correction fluid please)*
- *Answer **all** questions*
- *Answer the questions in the space provided*
- *Show all of the steps in any calculations and remember to include units*
- *You may use a calculator*
- *Use the periodic table provided*
- *Marks available for each question are indicated in brackets*
- Total marks for this paper 100

The Periodic Table of the Elements

1	2											3	4	5	6	7	0
							1 **H** hydrogen 1										4 **He** helium 2
7 **Li** lithium 3	9 **Be** beryllium 4											11 **B** boron 5	12 **C** carbon 6	14 **N** nitrogen 7	16 **O** oxygen 8	19 **F** fluorine 9	20 **Ne** neon 10
23 **Na** sodium 11	24 **Mg** magnesium 12											27 **Al** aluminium 13	28 **Si** silicon 14	31 **P** phosphorus 15	32 **S** sulfur 16	35.5 **Cl** chlorine 17	40 **Ar** argon 18
39 **K** potassium 19	40 **Ca** calcium 20	45 **Sc** scandium 21	48 **Ti** titanium 22	51 **V** vanadium 23	52 **Cr** chromium 24	55 **Mn** manganese 25	56 **Fe** iron 26	59 **Co** cobalt 27	59 **Ni** nickel 28	63.5 **Cu** copper 29	65 **Zn** zinc 30	70 **Ga** gallium 31	73 **Ge** germanium 32	75 **As** arsenic 33	79 **Se** selenium 34	80 **Br** bromine 35	84 **Kr** krypton 36
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[98] **Tc** technetium 43	101 **Ru** ruthenium 44	103 **Rh** rhodium 45	106 **Pd** palladium 46	108 **Ag** silver 47	112 **Cd** cadmium 48	115 **In** indium 49	119 **Sn** tin 50	122 **Sb** antimony 51	128 **Te** tellurium 52	127 **I** iodine 53	131 **Xe** xenon 54
133 **Cs** caesium 55	137 **Ba** barium 56	139 **La*** lanthanum 57	178 **Hf** hafnium 72	181 **Ta** tantalum 73	184 **W** tungsten 74	186 **Re** rhenium 75	190 **Os** osmium 76	192 **Ir** iridium 77	195 **Pt** platinum 78	197 **Au** gold 79	201 **Hg** mercury 80	204 **Tl** thallium 81	207 **Pb** lead 82	209 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

**** The lanthanoids (atomic numbers 58-71) and the actinoids (atomic numbers 90-103) have been omitted.***

The relative atomic masses of copper and chlorine have not been rounded to the nearest whole number.

1(a). This question is about structure and bonding.

Look at the two structures, **A** and **B**, in **Fig. 16.1**.

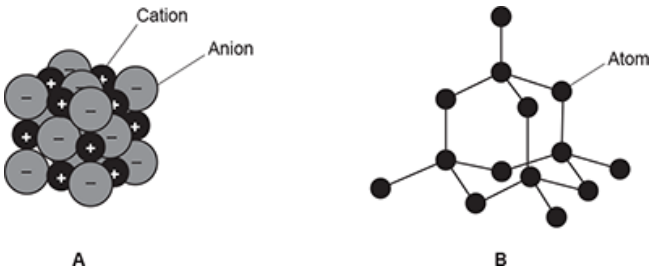

Fig. 16.1

i. Identify the bonding in structure **A**.

Explain your answer.

Bonding

Explanation

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[2]

ii. Explain why structure **B** has a high melting point.

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[2]

iii. Explain why structure **B** does **not** conduct electricity.

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[1]

b. Look at the structure of a metal in **Fig. 16.2**. Metals are malleable, which means they can be hammered or pressed into shape without breaking or cracking.

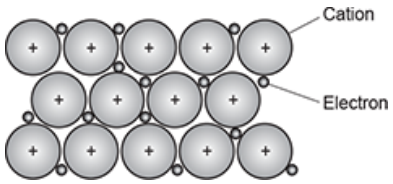

Fig. 16.2

Explain why metals are **malleable**.

---**[2]**

(b). Look at the structure of a metal in **Fig. 16.2**. Metals are malleable, which means they can be hammered or pressed into shape without breaking or cracking.

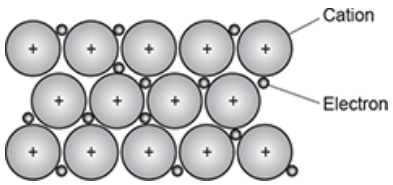

Fig. 16.2

Explain why metals are **malleable**.

---**[2]**

2(a). A student is investigating chemical reactions that produce heat.

She adds zinc to hydrochloric acid, HC*l* .

Zinc chloride, ZnC*l* $_2$, and hydrogen gas are made.

i. Write the **balanced symbol** equation for this reaction.

---**[2]**

ii. What term is used to describe a reaction that produces heat?

---**[1]**

(b). The student draws the reaction profile for this reaction, as shown in **Fig. 18.1**.

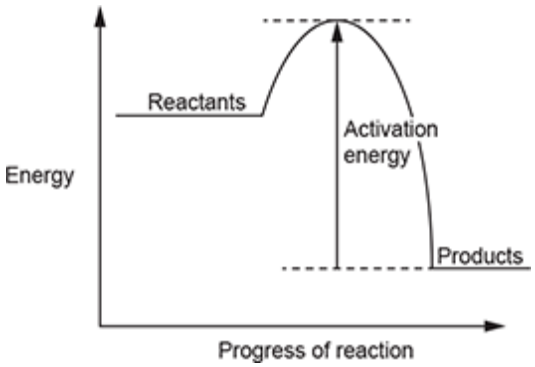

Fig. 18.1

Explain what is meant by the term **activation energy**.

---

[1]

(c). Combustion reactions produce a lot of heat energy.

Bond energies can be used to calculate the energy change in combustion reactions.

Bond	Bond energy (kJ / mol)
C–H	413
O=O	498
C=O	805
O–H	464

Methane is a common fuel used in combustion reactions.

Methane reacts with oxygen. Carbon dioxide and water are made, as shown in **Fig. 18.2**.

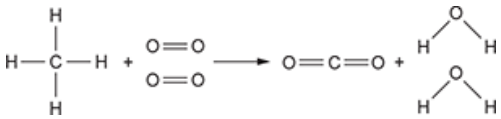

Fig. 18.2

i. The reaction of methane with oxygen produces heat.

Explain why.

Use ideas about bond breaking and bond making in your answer.

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[3]

ii. Calculate the total energy transferred to break the bonds in the reactants in **Fig. 18.2**.

Total energy transferred = ... kJ / mol **[1]**

iii. Calculate the total energy transferred to make the bonds in the products in **Fig. 18.2**.

Total energy transferred = ... kJ / mol **[1]**

iv. Use your answers to parts **(ii)** and **(iii)** to calculate the energy change for the reaction in **Fig. 18.2**.

Energy change = ... kJ / mol **[1]**

3.

i. Mendeleev did not predict the existence of argon, neon, krypton or xenon.

The electron arrangement of argon is 2,8,8.

What does this tell you about the reactivity of argon?

Explain your answer.

---

[2]

ii. Neon is an element that has isotopes. Two of the isotopes are shown below.

$^{20}_{10}Ne$ $^{22}_{10}Ne$

Complete **Table 17.3** to show the number of protons, neutrons and electrons in each neon isotope.

	$^{20}_{10}Ne$	$^{22}_{10}Ne$
Proton		
Neutron		
Electron		

Table 17.3 **[3]**

4. After testing some soil samples, a farmer finds that the soil in one of his fields is acidic.

Acidic soil can be neutralised by spreading magnesium carbonate, $MgCO_3$, onto the soil.

The farmer uses 25.0 kg of magnesium carbonate.

Calculate the number of moles of magnesium carbonate the farmer uses.
(A_r: C = 12.0; Mg = 24.3; O = 16.0)

Give your answer to **3** significant figures.

Number of moles of magnesium carbonate = ... **[3]**

5(a). Sodium oxide, Na_2O, is a white solid.

Draw a dot and cross diagram to show the ions in sodium oxide.

[2]

(b).

i. Sodium oxide reacts with water.

An aqueous solution of sodium hydroxide is made.

Write the **balanced symbol equation** for this reaction, including **state symbols**.

[3]

ii. Sodium hydroxide neutralises acids. It is an alkali.

Which ion do solutions of alkalis contain?

[1]

iii. A salt is made when sodium hydroxide neutralises sulfuric acid.

Name this salt.

[1]

iv. A sample of hydrochloric acid has a pH of 1.04.

A student adds water to the hydrochloric acid until the pH is 3.04.

The concentration of hydrogen ions decreases.

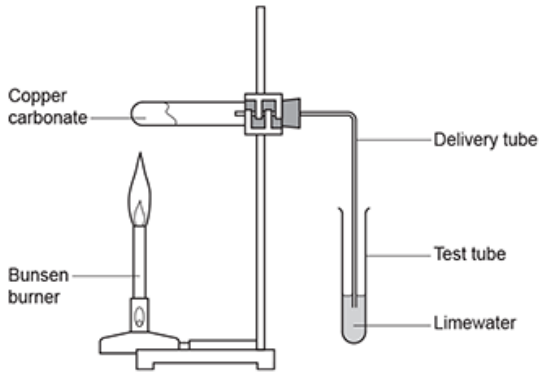
Calculate the factor by which the hydrogen ion concentration has decreased.

Decrease in hydrogen ion concentration = ... **[2]**

6(a). A student investigates the thermal decomposition of copper carbonate.

copper carbonate → copper oxide + carbon dioxide

Here is the set-up of the apparatus she uses.



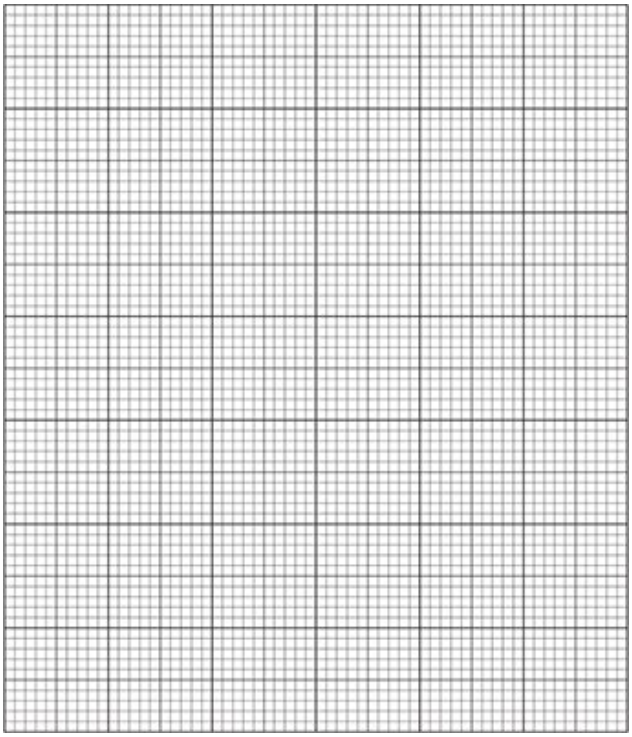
The student measures the mass of copper carbonate at the start of the experiment. She then measures the mass of copper oxide made.

She does the experiment five times using a different mass of copper carbonate each time.

Look at her results.

Mass of copper carbonate (g)	Mass of copper oxide (g)
1.00	0.70
2.00	1.35
3.00	1.95
4.00	2.65
5.00	3.30

i. Plot a graph of the student's results and draw a line of best fit.



[4]

ii. What is the mass of copper carbonate that needs to be heated to produce 2.50 g of copper oxide?

Use your graph in your answer.

Mass of copper carbonate = ... g **[1]**

iii. The mass of copper oxide made in the reaction is less than the mass of the copper carbonate heated.

Suggest why.

---**[1]**

(b). Calcium carbonate thermally decomposes to make calcium oxide and carbon dioxide.

$CaCO_3 \rightarrow CaO + CO_2$

Calculate the mass of calcium carbonate needed to make 209g of calcium oxide.

(A_r: Ca = 40.1, C = 12.0, O = 16.0)

Give your answer to **3** significant figures.

Mass of calcium carbonate = ... g **[4]**

7. A student investigates the decomposition of hydrogen peroxide.

$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$

0.2g of oxygen gas is produced in the reaction.

The student uses 0.5 g of manganese(IV) oxide as a catalyst in the reaction.

How much manganese(IV) oxide remains at the end of the reaction?

A 0.2g
B 0.3g
C 0.5g
D 0.7g

Your answer ☐ **[1]**

8. The formula of ammonium carbonate is $(NH_4)_2CO_3$.

What is the relative formula mass of ammonium carbonate?
(A_r: C = 12, H = 1, N = 14, O = 16)

A 78
B 90
C 96
D 120

[1]

Your answer ☐

9. Which purification technique is used to separate ethanol and water from a mixture?

A Chromatography
B Distillation
C Evaporation
D Filtration

Your answer ☐ **[1]**

10. Magnesium reacts with chlorine. Magnesium chloride is made.

What is the balanced symbol equation for this reaction?

A $Mg + Cl \rightarrow MgCl$

B $Mg + Cl_2 \rightarrow MgCl_2$

C $2Mg + Cl_2 \rightarrow 2MgCl$

D $2Mg + Cl_2 \rightarrow Mg_2Cl_2$

Your answer ☐ **[1]**

11. Which Period 3 element is in Group 2?

A Aluminium

B Boron

C Calcium

D Magnesium

Your answer ☐ **[1]**

12. Carbon-12 and carbon-14 are isotopes.

Which statement describes isotopes?

A Atoms with the same number of protons but a different number of electrons.

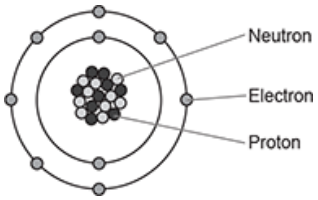
B Atoms with the same number of electrons but a different number of protons.

C Atoms with the same number of protons but a different number of neutrons.

D Atoms with the same number of neutrons but a different number of protons.

Your answer ☐ **[1]**

13. The diagram shows an atom of an element.



What is the name of the element?

A Boron
B Beryllium
C Fluorine
D Neon

Your answer ☐ **[1]**

14. The charge on an electron is -1.6×10^{-19} C.

What is the charge on a proton?

A -1.6×10^{19} C
B -1.6×10^{-19} C
C 1.6×10^{-19} C
D 1.6×10^{19} C

Your answer ☐ **[1]**

15. Ammonia has a simple molecular structure.

Which statement explains why ammonia has a low melting point and a low boiling point?

A The covalent bonds between the atoms are strong.
B The covalent bonds between the atoms are weak.
C The intermolecular forces between the molecules are strong.
D The intermolecular forces between the molecules are weak.

Your answer ☐ **[1]**

16. Graphite is a form of carbon. Graphite can conduct electricity.

Why can graphite conduct electricity?

A Delocalised electrons are between layers.
B The ions can move.
C Layers have weak intermolecular forces.
D Strong covalent bonds are between the carbon atoms.

Your answer ☐ **[1]**

17. Avogadro's constant has a value of 6.02×10^{23}.

What is the number of atoms in 0.5 mol of water?

A 2.00×10^{23}
B 3.01×10^{23}
C 6.02×10^{23}
D 9.03×10^{23}

Your answer ☐ **[1]**

18. Magnesium powder reacts with copper(II) oxide. Magnesium oxide and copper are made.

$Mg + CuO \rightarrow MgO + Cu$

Which substance is the **reducing agent**?

A Magnesium
B Copper oxide
C Magnesium oxide
D Copper

Your answer ☐ **[1]**

19. Sodium hydroxide reacts with hydrochloric acid. Sodium chloride and water are made.

$NaOH + HCl \rightarrow NaCl + H_2O$

What mass of sodium hydroxide would be needed to make 46.8 g of sodium chloride?

A 16 g
B 32 g
C 50 g
D 64 g

Your answer ☐ **[1]**

20. Which equation shows the formation of a Group 2 metal ion?

M represents a Group 2 metal and e^- represents an electron.

A $M + e^- \rightarrow M^+$
B $M + 2e^- \rightarrow M^{2+}$
C $M \rightarrow M^+ + e^-$
D $M \rightarrow M^{2+} + 2e^-$

Your answer ☐ **[1]**

21. The accurate relative atomic mass of aluminium is 26.9815385.

What is this number to **5** significant figures?

A 26.98153
B 26.981
C 26.98154
D 26.982

Your answer ☐ **[1]**

22. Phosphoric acid contains phosphate ions, PO_4^{3-}.

Phosphoric acid is completely neutralised by sodium hydroxide.

What is the formula of the salt that is made?

A Na_2PO_4
B Na_3PO_4
C $Na(PO_4)_3$
D $Na_2(PO_4)_3$

Your answer ☐ **[1]**

23(a). Sodium is in Group 1 of the Periodic Table.

Sodium reacts with water to make sodium hydroxide, NaOH, and hydrogen.

Write the **balanced symbol** equation for the reaction between sodium and water.

[2]

(b). Sodium ions, Na^+, are formed when sodium reacts with water.

Look at the equation. It shows how a sodium ion is formed from a sodium atom.

$Na - e^- \rightarrow Na^+$

The symbol e^- means an electron.

The formation of a sodium ion from a sodium atom is an example of **oxidation**.

Explain why.

[1]

(c). Rubidium is another element in Group 1.

Rubidium reacts much faster than sodium does.

Explain why.

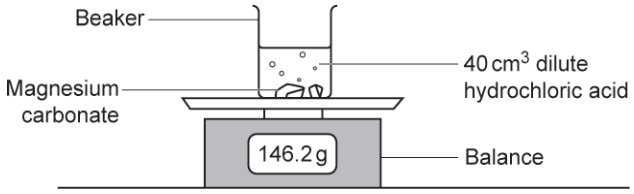
Use ideas about electrons in your answer.

[2]

24(a). A student investigates the rate of reaction between dilute hydrochloric acid and magnesium carbonate.

She wants to find out how the concentration of the acid changes the rate of reaction.

Look at the apparatus she uses.



Carbon dioxide gas is given off in the reaction.

The student measures the loss in mass every 30 seconds for 5 minutes.

Another student also investigates the rate of reaction between dilute hydrochloric acid and magnesium carbonate.

He also wants to find out how the **concentration** of the acid changes the rate of reaction. He uses a **different** method.

Describe the **method** he uses.

Include a **labelled diagram** of the setup of the apparatus he uses.

---

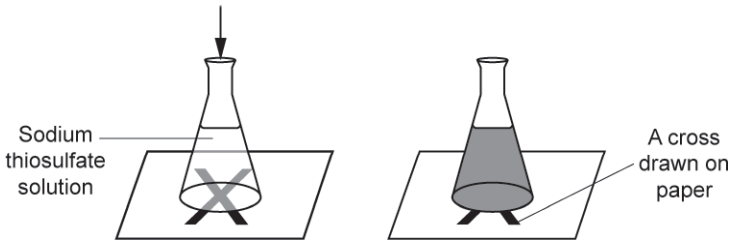
[5]

(b). Some students investigate the reaction between sodium thiosulfate and dilute hydrochloric acid.

They want to find out how **temperature** changes the rate of reaction.

Look at the diagram of their experiment.

Add dilute hydrochloric acid and start timing



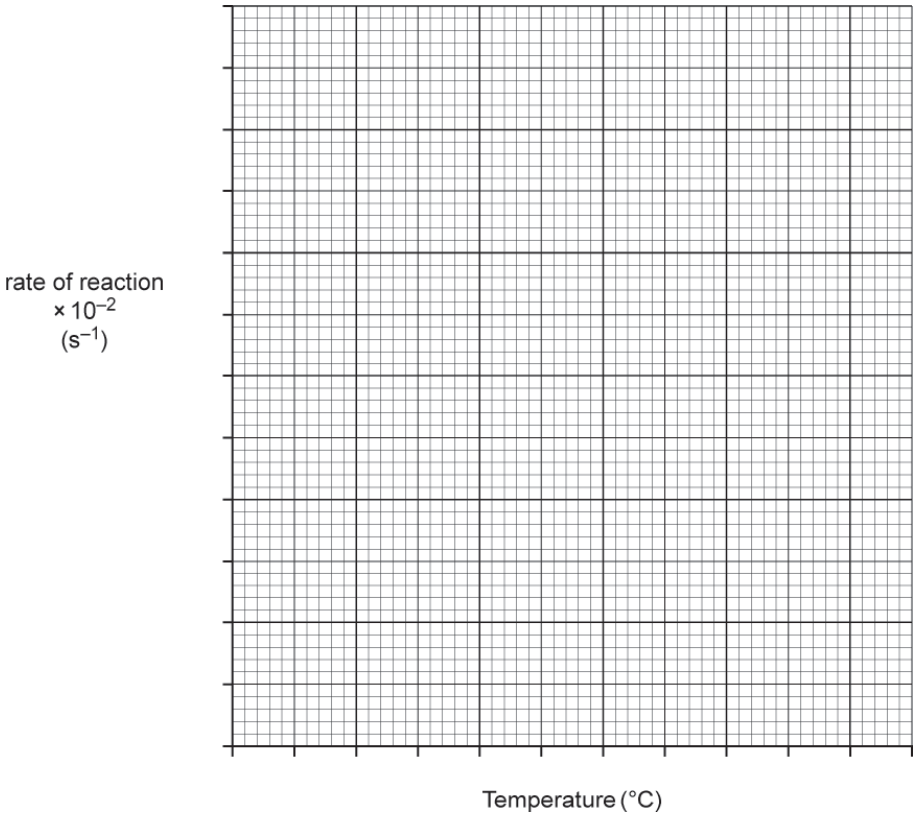
A yellow solid is made during the reaction.

The students time how long it takes for the cross to disappear. This is the reaction time.

Look at their results.

Temperature (°C)	Reaction time (s)	Rate of reaction (s^{-1})
10	140	7×10^{-3}
20	56	2×10^{-2}
30	34	3×10^{-2}
40	26	4×10^{-2}
50	22	5×10^{-2}

i. Plot a graph of the results on the grid. Draw a line of best fit.



[4]

ii. What happens to the **rate of reaction** as the temperature increases?

[1]

iii. Explain your answer to **(ii)**.

Use ideas about collisions between particles in your answer.

[3]

25. * A student has unlabelled samples of three liquids.

The student knows that the three liquids are:

- pentane, C_5H_{12}
- pentene, C_5H_{10}
- ethanoic acid, CH_3COOH.

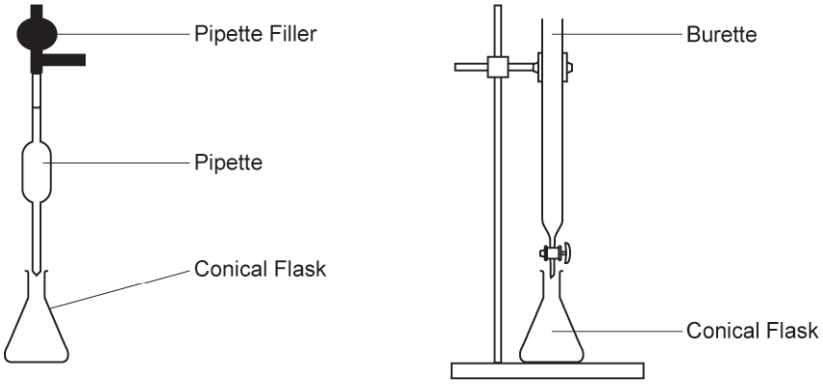
Describe tests that the student should do to identify each of the three liquids.

Include **balanced symbol** equations for the reactions described.

[6]

26(a). A student neutralises potassium hydroxide with dilute sulfuric acid in a titration experiment.

Look at the student's method for her experiment.



- Measure 25.0 cm^3 of 0.200mol / dm^3 potassium hydroxide into a conical flask using a pipette.
- Add a few drops of universal indicator to the potassium hydroxide.
- Fill the burette to above the 0.00 cm^3 line with dilute sulfuric acid.
- Quickly add the dilute sulfuric acid to the potassium hydroxide until the indicator changes colour.
- Repeat the experiment.

Describe and explain **one** improvement the student should make to her method to get a more accurate titration result.

---

[2]

(b). The student repeats the experiment four times.

Look at the student's results.

Titration number	1	2	3	4
Volume of acid (cm^3)	25.75	23.60	23.70	23.65

i. Calculate the **accurate** volume of the acid that reacts with the alkali.

Accurate volume of acid = ... cm^3 **[2]**

ii. Look at the equation for the reaction between sulfuric acid and potassium hydroxide.

$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$

Use your answer from part **(i)** to calculate the concentration of the dilute sulfuric acid, H_2SO_4, that reacted with the 25.0 cm^3 of 0.200mol / dm^3 potassium hydroxide.

Give your answer to **3** significant figures.

Concentration of dilute sulfuric acid = ... mol / dm^3 **[4]**

27(a). A student investigates the reactivity of four metals, **A**, **B**, **C** and **D**.

He adds a small piece of each metal to cold water.

He then adds a small piece of each metal to dilute hydrochloric acid.

Look at his results.

"

Metal	Observations in water	Observations in dilute hydrochloric acid
A	slow bubbling	very fast bubbling
B	no reaction	no reaction
C	fast bubbling	very fast bubbling
D	no change	slow bubbling

Write down the order of reactivity of the four metals **A**, **B**, **C** and **D**.

..... **most reactive**

.....

.....

..... **least reactive** **[2]**

(b). The piece of metal **C** used by the student produces 30 cm^3 of hydrogen gas when it reacts with the dilute hydrochloric acid at room temperature and pressure.

i. Calculate the number of **moles** of hydrogen gas produced.

One mole of any gas occupies 24 dm^3 at room temperature and pressure.

Moles of hydrogen gas = ... **[2]**

ii. Use your answer from **(i)** to calculate the **mass** of hydrogen gas produced.

Mass of hydrogen gas = ... g **[1]**

(c). Chromium metal, Cr, reacts with nickel sulfate solution, $NiSO_4$. Solid nickel is made.

Two possible equations for this reaction are:

Equation 1 $Cr + NiSO_4 \rightarrow CrSO_4 + Ni$

Equation 2 $2Cr + 3NiSO_4 \rightarrow Cr_2(SO_4)_3 + 3Ni$

10.40 g of chromium metal reacts with excess nickel sulfate solution to make 17.61 g of nickel.

Deduce which equation, **1** or **2**, represents the reaction which takes place.

A_r: Cr = 52.0, Ni = 58.7

---**[3]**

END OF QUESTION PAPER