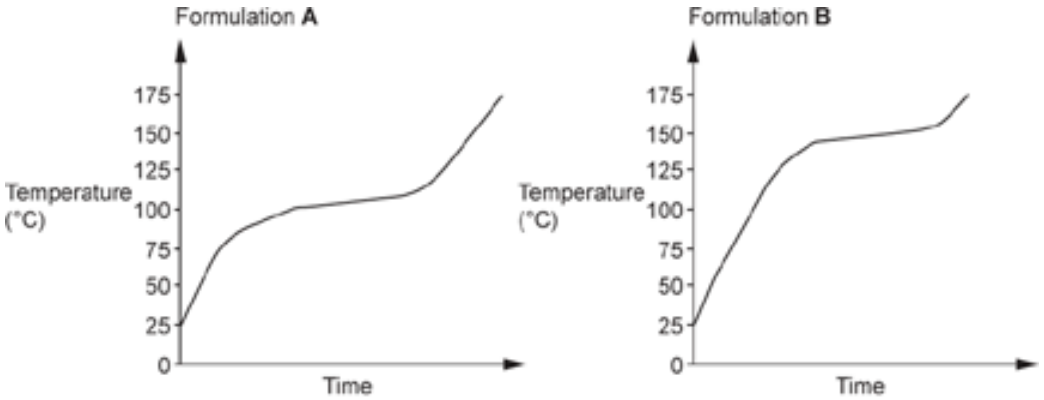
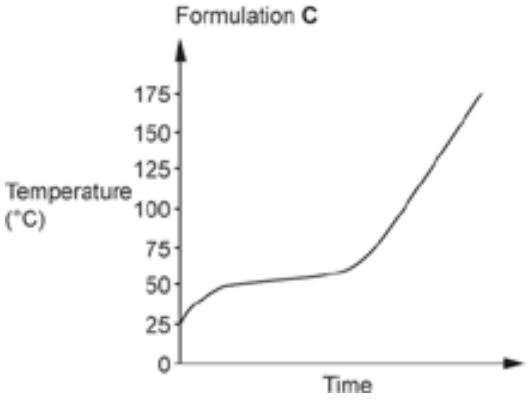
1. A scientist needs to choose a **solid** formulation that will be used at **high** temperatures.

The graphs show how the temperature changes as three different formulations, **A, B** and **C**, are heated.





Which formulation should the scientist choose?

Explain your answer.

Formulation _____

Explanation _____

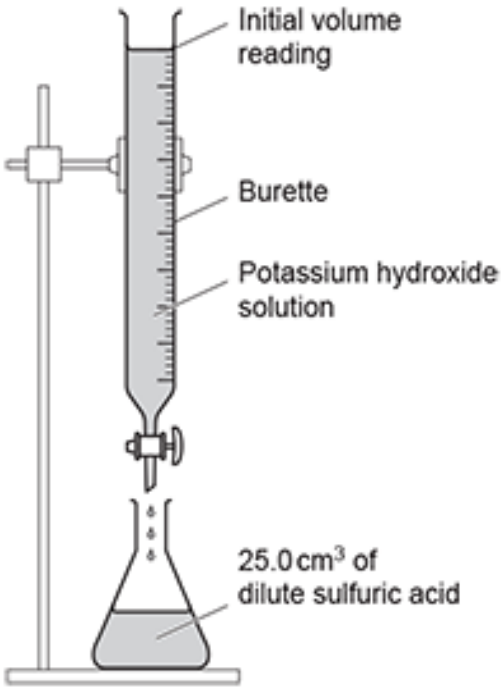
_____

_____

_____ **[2]**

2(a). A student plans a titration experiment.

The diagram shows some of the apparatus they use.



At the end of the titration, the student reads the final volume reading from the top of the meniscus instead of from the bottom of the meniscus.

How does the measured volume of potassium hydroxide compare to the actual volume?

Tick (✓) **one** box.

The measured volume will be greater than the actual volume. ☐

The measured volume will be smaller than the actual volume. ☐

The measured volume will be the same as the actual volume. ☐

[1]

(b). The student uses a potassium hydroxide solution with a concentration of 0.100 mol / dm^3 to neutralise the 25.0 cm^3 of dilute sulfuric acid.

The table shows the student's results.

Titration number	**1**	**2**	**3**	**4**
Final burette reading (cm^3)	24.1	26.6	26.0	26.8
Initial burette reading (cm^3)	0.0	1.5	2.1	2.8
Titre (volume of potassium hydroxide solution used) (cm^3)	24.1	25.1	23.9	24.0

i. Calculate the average titre using the student's concordant results.

Average titre = ... cm^3 **[1]**

ii. This is the equation for the reaction in this experiment.

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

Calculate the concentration of sulfuric acid in **g / dm^3** .

Relative atomic mass (A_r): H = 1.0 O = 16.0 S = 32.0

Concentration of sulfuric acid = ... g / dm^3 **[5]**

3(a). A scientist has a sample of seawater. The sample contains sand, water and salt.

The scientist wants to collect **pure** samples of:

- sand
- water
- salt.

Describe a method the scientist could use to separate and collect the sand, water and salt.

You can include labelled diagrams in your answer.

---**[4]**

(b). Seawater can contain isotopes of sulfur.

i. Draw **three** lines to connect each **isotope** with its correct **description**.

Isotope	Description
$^{16}_{32}S$	This isotope contains 17 neutrons.
$^{16}_{33}S$	This isotope has a full outer shell of electrons.
$^{16}_{34}S$	This isotope has more protons than neutrons.
	This isotope has the highest mass number.
	This isotope has the same number of neutrons and protons.

[2]

ii. Some of this sulfur in seawater is in the form of magnesium sulfate, $MgSO_4$.

What is the relative formula mass of a sample of magnesium sulfate, $MgSO_4$, where all of the sulfur atoms are the isotope sulfur-33?

Sulfur-33 is $^{16}_{33}S$

Relative atomic mass (A_r): O = 16.0 Mg = 24.3

Relative formula mass = ... **[2]**

iii. A scientist wants to separate magnesium sulfate from other compounds using thin layer chromatography.

The spot does **not** move from the start line on the chromatogram.

State what the scientist should change so that magnesium sulfate is separated from the other compounds.

---

[1]

iv. Explain why magnesium sulfate has a high melting point.

---**[2]**

4. A student investigates some samples using gas chromatography.

The student also measures the melting point of each sample.

Which results should the student expect from a **pure** sample?

	Gas chromatogram	Melting point (°C)
A	3 peaks	123–127
B	1 peak	123–127
C	2 peaks	125
D	1 peak	125

Your answer ☐ **[1]**

5. Which fraction is collected at the top of the fractional distillation column?

	Melting point range (°C)	Boiling point range (°C)
A	–70 – –60	20 – 25
B	–50 – –40	30 – 50
C	0 – 20	100 – 120
D	20 – 40	130 – 160

Your answer ☐ **[1]**

6. The empirical formula of a compound is CH_2O.

The relative formula mass of the compound is 180.0.

What is the **molecular formula** of the compound?

Relative atomic mass (A_r): C = 12.0 H = 1.0 O = 16.0

A $C_4H_8O_4$
B $C_5H_{10}O_5$
C $C_6H_{12}O_6$
D $C_7H_{14}O_7$

Your answer ☐ **[1]**

7. Which equipment is needed for distillation?

A Condenser, funnel, thermometer
B Condenser, round-bottomed flask, thermometer
C Thermometer, beaker, pH probe
D Thermometer, measuring cylinder, filter paper

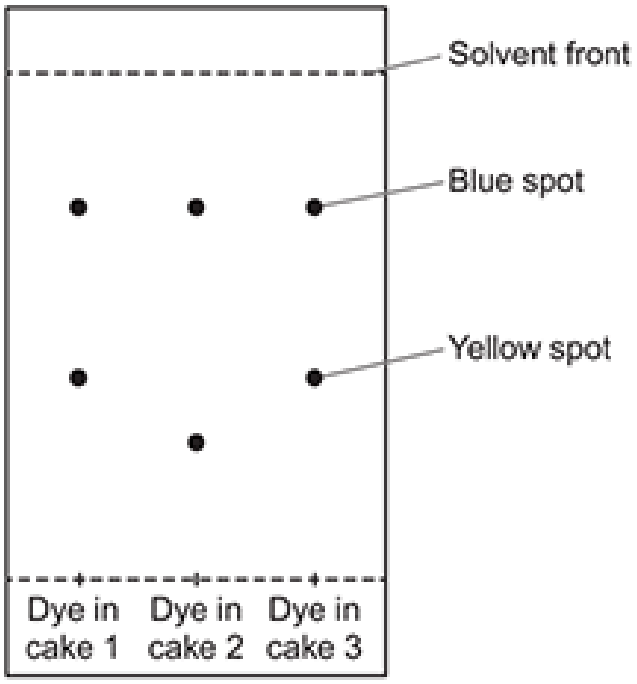
Your answer ☐ **[1]**

8(a). Three cakes each contain a different brand of food colouring dye.

- The colour is the same in each cake, but the taste in one is different.
- The cakes' baker thinks it is because of the food colouring dye.

The baker compares the food colouring dyes that were used in the three different cakes using thin layer chromatography. The chromatogram is shown in **Fig. 20.1**.

Fig. 20.1



i. Calculate the R_f value of the blue spot in the dye in cake 3.

Give your answer to **2** significant figures.

R_f value of blue spot in the dye in cake 3 = ... **[3]**

ii. Which of the cakes would you expect to taste the same?

Explain your answer using data from **Fig. 20.1**.

[2]

(b). The baker thinks the dyes are mixtures where the substances are combined in exact amounts.

i. What is the name given to this type of mixture?

_____ **[1]**

ii. Brass is also a mixture of different substances combined in exact amounts.

What type of substance is brass?

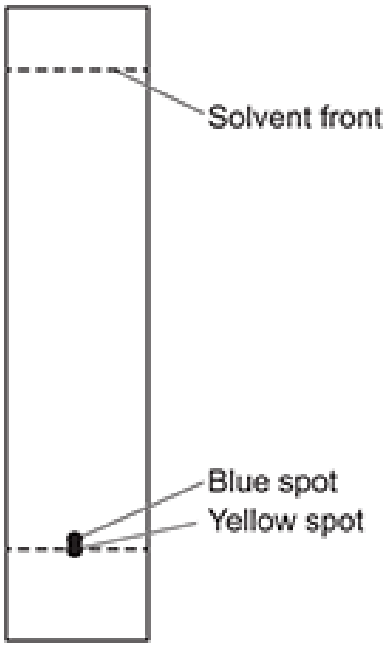
Tick (✓) **one** box.

Allotrope	☐
Alloy	☐
Fullerene	☐
Isotope	☐
Polymer	☐

[1]

(c). The student tests another dye. The chromatogram is shown in **Fig. 20.2**.

Fig. 20.2



What should the student change in their experiment to separate the blue and yellow spots?

_____ **[1]**

9. A student neutralises dilute sulfuric acid, H_2SO_4, with ammonia, NH_3, to make ammonium sulfate, $(NH_4)_2SO_4$.

This is the equation for the reaction.

$H_2SO_4 + 2NH_3 \rightarrow (NH_4)_2SO_4$

The student makes 4.22 g of ammonium sulfate. The percentage yield is 80%.

Calculate the **mass of sulfuric acid** the student used in the reaction.

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

Relative atomic mass (A_r): H = 1.0 N = 14.0 O = 16.0 S = 32.1

Mass of sulfuric acid = ... g **[5]**

10. A scientist investigates the melting point of some substances that may contain paracetamol as shown in the table.

The melting point of pure paracetamol is 169 °C.

Substance	Melting point (°C)
1	169
2	156
3	166 – 169
4	170 – 174

Which statement about the results is correct?

A All of the substances contain paracetamol.
B Substance 2 does not contain paracetamol.
C Substance 3 is pure paracetamol.
D Substance 4 is impure paracetamol.

Your answer ☐ **[1]**

11. A sample of propanoic acid, $C_3H_6O_2$, is made using an isotope of hydrogen, called deuterium.

The relative atomic mass of deuterium is 2.0.

What is the relative molecular mass, M_r, of propanoic acid when deuterium atoms replace all the hydrogen atoms?

A 68.0
B 74.0
C 80.0
D 86.0

Your answer ☐ **[1]**

12. An alloy that contains silver, copper and tin has 96% tin and 2.5% copper. The rest is silver.

What is the mass of silver in 12.0 g of the alloy?

A 0.18 g
B 0.3 g
C 1.8 g
D 3.0 g

Your answer ☐ **[1]**

13. A student wants to separate substances by filtration.

They write a method for the experiment but **not** in the correct order as shown.

1. Pour the mixture through the funnel into the conical flask.
2. Fold the filter paper.
3 Collect the filtrate in the conical flask.
4. Put the filter paper into the funnel.
5. Collect any insoluble substances on the filter paper.

What is the correct method order for this experiment?

A 1, 2, 4, 5, 3
B 2, 1, 4, 5, 3
C 2, 4, 1, 5, 3
D 4, 2, 5, 3, 1

Your answer ☐ **[1]**