OCR GCSE GATEWAY CHEMISTRY A · J248

CHEMISTRY



EXAM QUESTION PACK

C2.1 PURITY AND SEPARATING MIXTURES

SCORE	PERCENTAGE
/213	%

STEMUP

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Gateway Chemistry A (9-1)

Purity and separating mixtures

Please note that you may see slight differences between this paper and the original.

Candidates answer on the Question paper.

OCR supplied materials:
Additional resources may be supplied with this paper.

Other materials required:
- Pencil
- Ruler (cm/mm)

Duration: Not set

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions, unless your teacher tells you otherwise.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Where space is provided below the question, please write your answer there.
- You may use additional paper, or a specific Answer sheet if one is provided, but you must clearly show your candidate number, centre number and question number(s).

INFORMATION FOR CANDIDATES

- The quality of written communication is assessed in questions marked with either a pencil or an asterisk. In History and Geography a *Quality of extended response* question is marked with an asterisk, while a pencil is used for questions in which *Spelling, punctuation and grammar and the use of specialist terminology* is assessed.
- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **213**.
- The total number of marks may take into account some 'either/or' question choices.

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1 The **molecular formula** of cyclohexane is C_6H_{12}.

What is the **empirical formula** of cyclohexane?

A CH
B CH_2
C C_6H_{12}
D $C_{12}H_{24}$

Your answer ☐

[1]

2 A student has a solution of ammonium sulfate.

Describe how he can obtain a pure dry sample of ammonium sulfate.

---

[1]

3 Tim is separating the colours in a sample of black ink using paper chromatography.

He puts a spot of black ink onto filter paper.

He dips the filter paper into ethanol in a beaker.

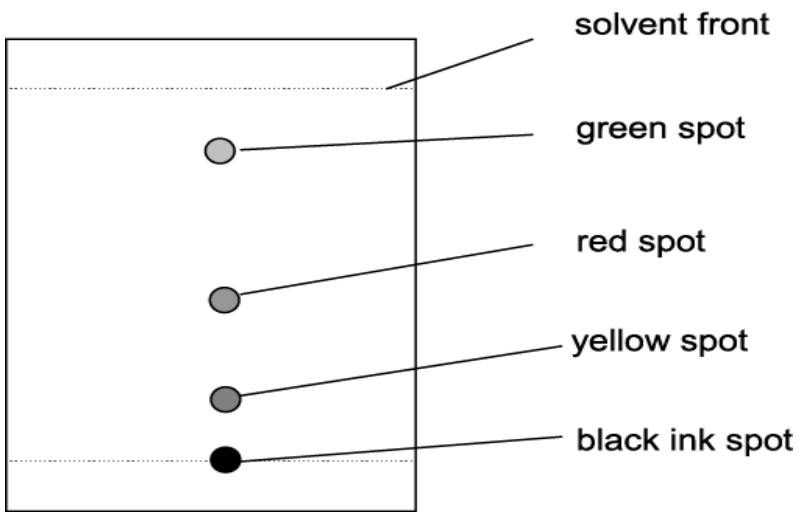
What is the name given to **ethanol** in this experiment?

A gas phase
B mobile phase
C solid phase
D stationary phase

Your answer ☐

[1]

4 Look at Tim's chromatogram.



What is the R_f value of the **green** spot? Use a ruler to help you.

A 0.17
B 0.42
C 0.83
D 1.00

Your answer ☐

[1]

5 The **molecular formula** of decene is $C_{10}H_{20}$.

What is the **empirical formula** of decene?

A CH_2
B C_2H_4
C C_5H_{10}
D $C_{20}H_{40}$

Your answer ☐

[1]

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6(a) A student is separating a mixture of three substances, **A**, **B** and **C**.

Look at the table. It gives information about these substances.

Substance	State at room temperature	Melting point (°C)	Boiling point (°C)	Solubility in water
A	liquid	0	100	soluble
B	liquid	–117	78	soluble
C	solid	1535	2750	insoluble

A and **B** mix together completely.

* Suggest how the student can separate the mixture to get pure samples of substances **A**, **B** and **C**.

Explain in detail how each method works.

[6]

(b) The student has separated a **pure** sample of substance **B** from the mixture.

Suggest how the student can check that the sample of substance **B** is pure.

---

[2]

7 Which technique is the best for separating pure water from a solution of sodium chloride in water?

A crystallisation
B chromatography
C filtration
D distillation

Your answer ☐

[1]

8 When 12 g of carbon, C, burns in oxygen, O_2, 44 g of carbon dioxide, CO_2, is formed.

What mass of C would need to burn to form 11 g of CO_2?

A 3 g
B 4 g
C 11 g
D 12 g

Your answer ☐

[1]

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9 Two isotopes of neon are:

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

Isotopes have different:

A numbers of protons
B numbers of neutrons
C charges
D numbers of electrons

Your answer ☐

[1]

10 What is the best description of the particles in a liquid?

	Distance between particles	Movement of particles
A	close together	in continuous random motion
B	close together	vibrating about a fixed point
C	far apart	in continuous random motion
D	far apart	vibrating about a fixed point

Your answer ☐

[1]

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11 Look at the table.

It shows some fractions made from the fractional distillation of crude oil and their boiling ranges.

Fraction	Boiling range (°C)
LPG	less than 25
petrol	85 – 105
diesel	150 – 290
fuel oil	290 – 380
bitumen	greater than 400

A hydrocarbon called eicosane has a boiling point which is 3.5 times the boiling point of petrol.

To which fraction does eicosane belong?

A diesel
B LPG
C fuel oil
D bitumen

Your answer ☐

[1]

12 The **molecular formula** of decene is $C_{10}H_{20}$.

What is the **empirical formula** of decene?

A CH_2
B C_2H_4
C C_5H_{10}
D $C_{20}H_{40}$

Your answer ☐

[1]

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13 Rosa tests some compounds to find out if they conduct electricity.

Which row in the table shows the correct results for each compound?

	Solid ionic compound	Ionic compound dissolved in water	Molten ionic compound
A	conducts	does not conduct	conducts
B	conducts	conducts	conducts
C	conducts	conducts	does not conduct
D	does not conduct	conducts	conducts

Your answer ☐

[1]

14 Copper sulfate solution can be electrolysed using non-inert copper electrodes.

Describe what happens at the negative copper electrode **and** the positive copper electrode.

---

[2]

15(a) Which element is oxidised and which element is reduced?

oxidised: _____

reduced: _____

[1]

(b) Magnesium burns in oxygen to make magnesium oxide.

The reaction involves both oxidation and reduction.

$$2Mg(....) + O_2(....) \longrightarrow 2MgO(s)$$

magnesium + oxygen → magnesium oxide

Complete the equation above by adding the state symbols for magnesium and oxygen at room temperature. [2]

16(a) Phil is a research chemist.

He investigates a new pharmaceutical drug.

Phil extracts the drug from the leaves of a plant.

He purifies the drug and then checks to see if he has made a pure sample.

Phil uses two tests to check the purity of the drug

- melting point
- thin layer chromatography.

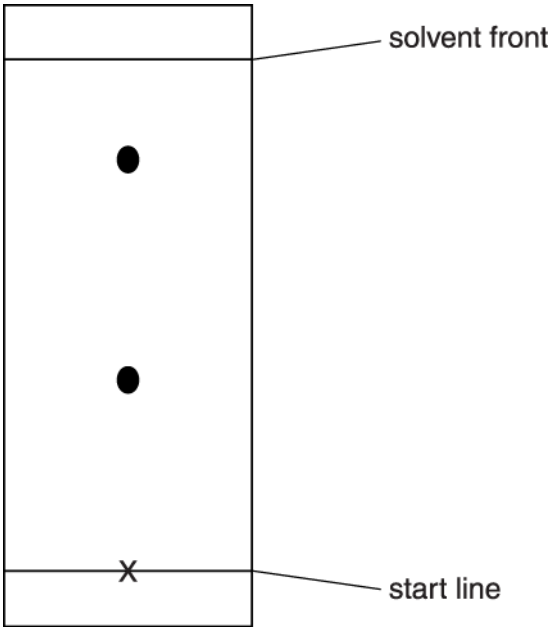
Look at the results of his tests.

Melting point

Substance	Melting point in °C
pure drug	175
sample of the drug obtained from plant	171 – 173

Thin layer chromatogram of sample of the drug obtained from the plant.

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Write about **how** a sample of the drug is obtained from the leaves of a plant.

What do the results of his tests show about the purity of the sample?

The quality of written communication will be assessed in your answer to this question.

[6]

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(b) Pharmaceutical drugs need to be thoroughly tested before they are allowed to be licensed to be sold.

Explain why.

---[2]

17 Sodium hydrogencarbonate decomposes when it is heated.

sodium hydrogencarbonate	→	sodium carbonate	+	carbon dioxide	+	water
$2NaHCO_3$	→	Na_2CO_3	+	CO_2	+	H_2O

The table shows the relative formula masses, M_r, of the substances in the equation.

Substance	Relative formula mass
$NaHCO_3$	84
Na_2CO_3	106
CO_2	44
H_2O	18

Show that the relative formula mass of Na_2CO_3 is 106.

The relative atomic mass, A_r, of C = 12, O = 16 and of Na = 23.

---[1]

18(a) This question is about metals and alloys.

Look at the list of materials.

amalgam

bronze

copper

mercury

solder

Some of the materials are **alloys**.

Some of the materials are **metallic elements**.

Finish the table. Put each material in the correct column.

One material has been done for you.

Alloy	Metallic element
	copper

[2]

(b) Look at the table. It shows the properties of some alloys.

Alloy	Density in g / cm^3	Relative strength	Relative cost
duralumin	2.8	high	high
brass	8.4	high	medium
steel	7.8	very high	low



Which alloy is most suitable for making aeroplane wings?

Use information from the table to give **two** reasons for your choice.

---**[2]**

19(a) Phil is a research chemist.

He investigates a new pharmaceutical drug.

Phil extracts the drug from the leaves of a plant.

He purifies the drug and then checks to see if he has made a pure sample.

Phil uses two tests to check the purity of the drug

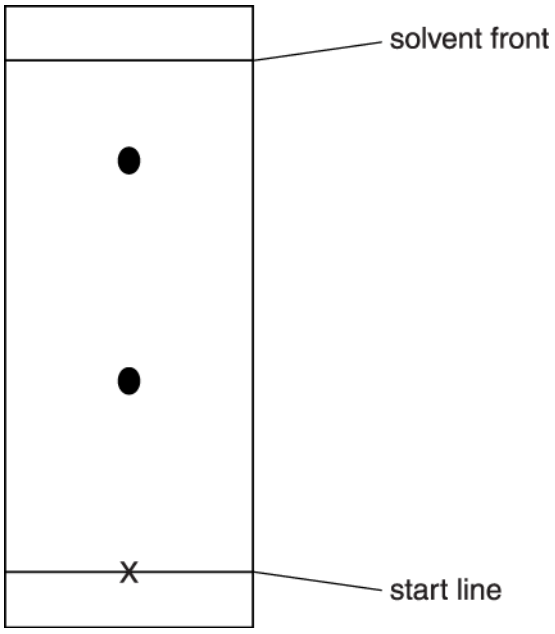
- melting point
- thin layer chromatography.

Look at the results of his tests.

Melting point

Substance	Melting point in °C
pure drug	175
sample of the drug obtained from plant	171 – 173

Thin layer chromatogram of sample of the drug obtained from the plant.



Write about **how** a sample of the drug is obtained from the leaves of a plant.

What do the results of his tests show about the purity of the sample?

The quality of written communication will be assessed in your answer to this question.

[6]

(b) It is difficult to test and develop new pharmaceutical drugs that are safe to use.
Explain why.

[2]

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20 This question is about metals and alloys.

Look at the table. It shows some alloys and the metals they contain.

Complete the table.

Alloy	Metal(s) in the alloy
amalgam	_____
_____	copper and zinc
solder	_____ and _____

[2]

21(a) The alloy duralumin contains aluminium.

Aluminium reacts with oxygen, O_2.

Aluminium oxide, Al_2O_3, is made.

Write a **balanced symbol** equation for this reaction.

_____ [2]

(b) Look at the table. It shows the properties of some alloys.

Alloy	Density in g / cm^3	Relative strength	Relative cost
A	2.8	high	high
B	8.4	high	medium
C	7.8	high	low
D	2.6	low	low



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(i) Evaluate the advantages and disadvantages of these alloys for making aeroplane wings.

Put your answers in the table below.

Alloy	Advantages	Disadvantages
A	_____ _____ _____	_____ _____ _____
B	_____ _____ _____	_____ _____ _____
C	_____ _____ _____	_____ _____ _____
D	_____ _____ _____	_____ _____ _____

[3]

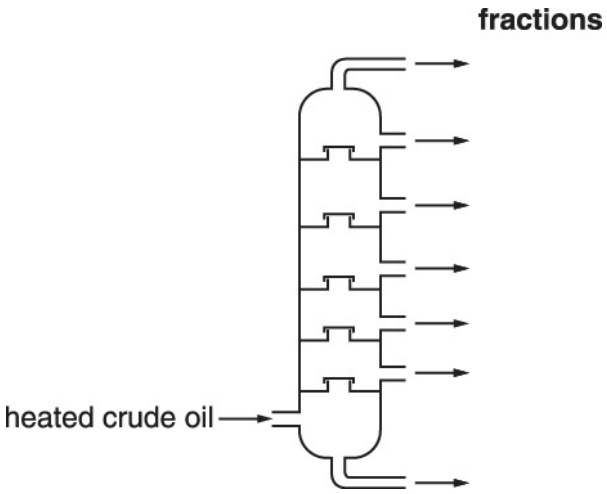
(ii) Which alloy would you choose?

_____ **[1]**

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22 Crude oil is separated into many fractions by fractional distillation.

The diagram shows a fractionating column.



Look at the table. It shows the boiling point range for some of the fractions.

Fraction	Boiling point range in °C
bitumen	above 350
heating oil	240 to 350
paraffin	120 to 240
petrol	20 to 70
LPG	−160 to 20

Write down the name of the fraction which 'exits' from the **bottom** of the fractionating column.

[1]

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23(a) Stowmarket Synthetics manufacture ethanoic acid, $C_2H_4O_2$, by two different processes.

Process **1** $C_2H_6O + O_2$? $C_2H_4O_2 + H_2O$

Process **2** CH_4O + ? CO $C_2H_4O_2$

Look at the table of relative formula masses.

Compound	Formula	Relative formula mass, *Mr*
ethanol	C_2H_6O	
oxygen	O_2	32
ethanoic acid	$C_2H_4O_2$	60
water	H_2O	18
methanol	CH_4O	32
carbon monoxide	CO	28

The relative atomic mass of H = 1, of C = 12, and of O = 16.

Calculate the relative formula mass of ethanol, C_2H_6O.

---

relative formula mass = _____

[1]

(b) In process **2** Stowmarket Synthetics use 320 g of methanol.

They make 600 g of ethanoic acid.

What mass of carbon monoxide do they need?

---

mass of carbon monoxide = _____ g

[1]

(c) Stowmarket Synthetics know that the **atom economy** of a process is important.

Water is a waste product in process **1**.

Show that the atom economy for making ethanoic acid by process **1** is 77%.

---

[2]

(d) Stowmarket Synthetics also know that the **percentage yield** of a process is important.

The factory uses 5.2 tonnes of methanol in process **2**.

A scientist predicts they should make 9.8 tonnes of ethanoic acid.

They actually make 9.5 tonnes of ethanoic acid.

Show that the percentage yield of ethanoic acid is 97%.

---

[2]

24(a) Space probes have been sent to Mars to analyse the soil.

One compound analysed has the formula, K_2FeO_4.

Calculate the molar mass of K_2FeO_4.

The relative atomic mass, A_r, of O = 16, of K = 39 and of Fe = 56.

molar mass = _____ g / mol

[1]

(b) A sample of K_2FeO_4 is analysed.

The 1.00 g sample contains 0.39 g of potassium and 0.28 g of iron.

(i) Calculate the mass of oxygen in this sample.

mass of oxygen = _____ g

[1]

(ii) Calculate the percentage by mass of oxygen in this sample of K_2FeO_4.

percentage by mass = _____ %

[1]

(c) Another compound found on Mars has the molecular formula C_4H_{10}.

What is the **empirical** formula for this compound?

_____

[1]

25 These substances are found in water before it is purified for drinking

- insoluble solids
- microbes.

How are **insoluble solids** and **microbes** removed from water to make it safe to drink?

_____

_____

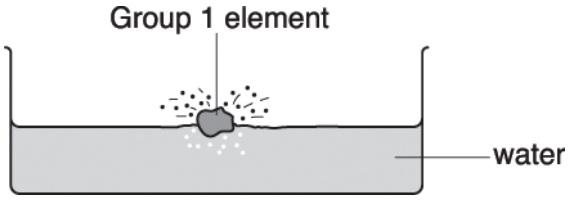
_____

_____ [2]

26 This question is about the reaction of Group 1 elements with water.

Lithium, sodium and potassium are Group 1 elements.

They react with water.



Look at the table.

Group 1 element	Time for 0.5 g of metal to react completely in seconds	Observations
sodium	15	melts moves across surface of water makes a gas which burns with a 'pop' makes an alkaline solution
potassium	7	melts and catches fire moves quickly across surface of water makes a gas which burns with a 'pop' makes an alkaline solution
lithium	25	moves slowly across surface of water makes a gas which burns with a 'pop' makes an alkaline solution

Rubidium is another Group 1 element.

It is below potassium in Group 1 of the periodic table.

When the same mass of rubidium reacts with water, **predict**

- what you will see
- the names of the products
- how long rubidium will take to react.

The quality of written communication will be assessed in your answer to this question.

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[6]

27(a) Space probes have been sent to Mars to analyse the soil.

One compound analysed has the formula $Ca(ClO_4)_2$.

Calculate the molar mass of $Ca(ClO_4)_2$.

The relative atomic mass, A_r, of O = 16, of Cl = 35.5 and of Ca = 40.

molar mass _____ g/mol

[1]

(b) Another compound found on Mars has the molecular formula C_4H_{10}.

What is the **empirical** formula for this compound?

_ _

[1]

(c) Another compound found on Mars contains iron and oxygen.

The compound contains 70% by mass of iron and 30% by mass of oxygen.

Calculate the empirical formula of this compound.

The relative atomic mass, *A*r, of O = 16 and of Fe = 56.

empirical formula is _

[3]

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28(a) There are many compounds that contain carbon and hydrogen only.

Pentane has the formula $CH_3(CH_2)3CH_3$.

Calculate the molar mass of pentane.

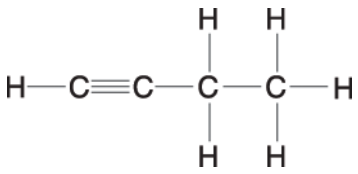
The relative atomic mass, A_r , of H = 1 and of C = 12.

---

molar mass = _____ g / mol

[1]

(b) Look at the displayed formula for butyne.



What is the **molecular formula** for butyne?

---

[1]

(c) Look at the molecular formula of some compounds.

Which **two** compounds have the same **empirical** formula?

Choose from

CH_4	C_2H_2	C_2H_4
C_2H_6	C_3H_4	C_6H_6

answer _____ and _____

[1]

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(d) David analyses a sample of a gas.

He finds it contains 1.2 g of carbon and 0.4 g of hydrogen.

Calculate the empirical formula for this gas.

---

empirical formula is _____

[2]

29 Look at the table. It shows information about the Group 1 metals.

Element	Symbol	Electronic structure	Melting point in °C	Boiling point in °C	Atomic radius in nm
lithium	Li	2.1	181	1342	0.152
sodium	Na	2.8.1	_____	883	0.185
potassium	K	2.8.8.1	64	760	0.227
rubidium	Rb	2.8.18.8.1	39	688	_____

Predict the melting point of sodium and the atomic radius of rubidium.

Write your answers in the table.

[2]

30(a) An element **X** has the electronic structure 2.8.8.2.

Explain how you can tell that element **X** is calcium.

---[1]

(b) Chlorine has the electronic structure 2.8.7.

Chlorine, Cl_2, is a covalent molecule.

Use the 'dot and cross' model to describe the bonding in a molecule of chlorine, Cl_2.

You only need to draw the outer shell electrons.

[2]

31(a) There are many compounds that contain carbon and hydrogen only.

Pentane has the molecular formula C_5H_{12}.

Calculate the molar mass of pentane.

The relative atomic mass, A_r, of H = 1 and of C = 12.

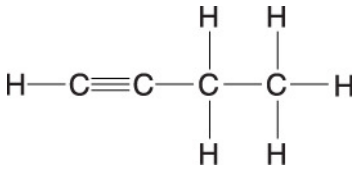
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molar mass = _____ g / mol

[1]

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(b) Look at the displayed formula for butyne.



What is the **molecular formula** for butyne?

---

[1]

(c) Look at the molecular formula of these compounds.

Which **two** compounds have the same **empirical** formula?

Choose from

CH_4	C_2H_2	C_2H_4
C_2H_6	C_3H_4	C_6H_6

answer _____ and _____

[1]

(d) David analyses a 1.6 g sample of methane, CH_4.

He finds it contains 1.2 g of carbon and 0.4 g of hydrogen.

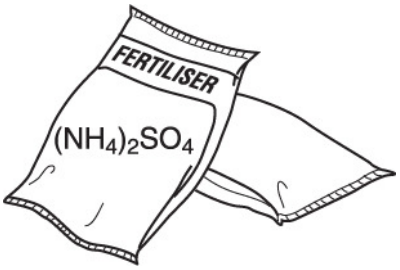
Calculate the percentage by mass of **carbon** in methane.

---

[1]

32 This question is about fertilisers.

Ammonium sulfate, $(NH_4)_2SO_4$, is used as a fertiliser.



Complete the table to show the number of **atoms of each element** in the formula for ammonium sulfate.

Element	Number of atoms
nitrogen	_____
hydrogen	_____
sulfur	_____
oxygen	_____

[1]

33 Fractional distillation separates crude oil into useful fractions.

The fractions have different boiling temperatures.

Look at the table.

It shows some information about fractions obtained from crude oil.

Fraction	Boiling temperature in °C
bitumen	above 350
LPG	less than 40
fuel oil	300 – 350
heating oil	250 – 300
petrol	40 – 200
paraffin	200 – 250

Use ideas about intermolecular forces to explain how fractional distillation separates crude oil into fractions and list the fractions in the position, from top to bottom, that they 'exit' the fractionating column.



The quality of written communication will be assessed in your answer to this question.

[6]

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34 When a pharmaceutical drug is manufactured it must be as pure as possible.

(i) Explain why it is important that the pharmaceutical drug is as pure as possible.

---

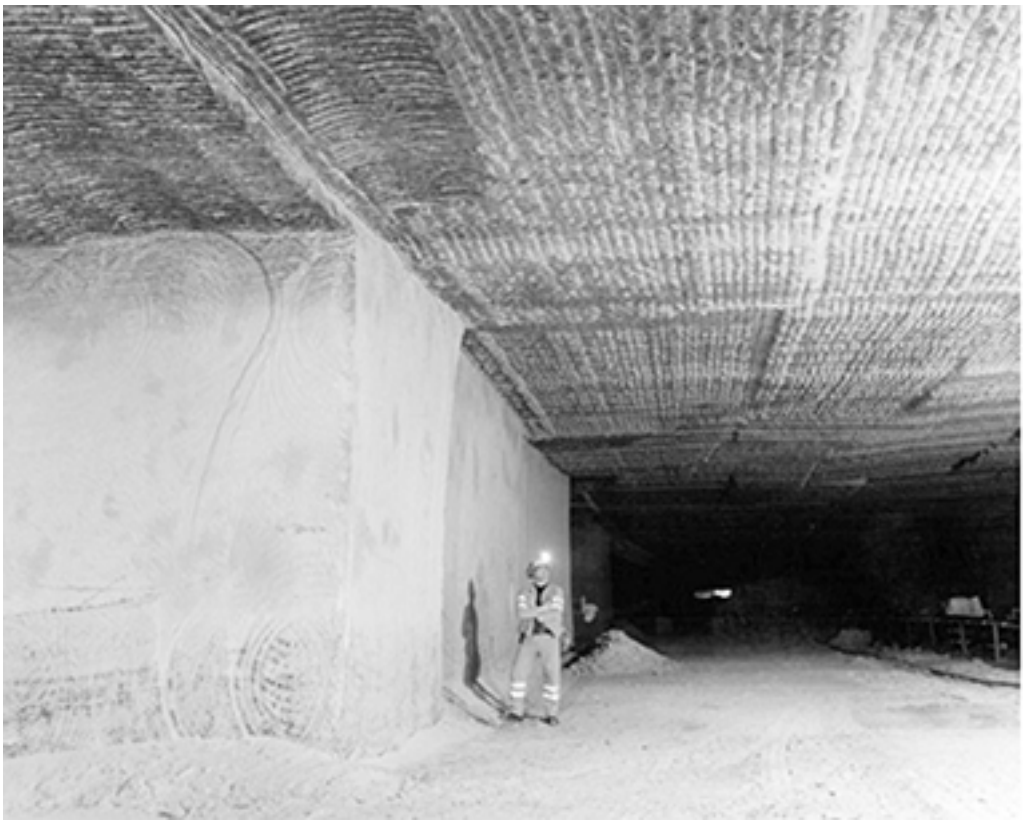
[1]

(ii) Write down **one** method a chemist can use to show that a pharmaceutical drug is pure.

---

[1]

35 Most of the UK's salt comes from the Winsford Salt Mine in Cheshire.



Describe one way that the salt can be extracted from the salt mine.

---

[1]

36 A mixture contains hexane, decane, hexadecane and icosane.

Which method can be used to separate this mixture?

Choose from

cracking

emulsification

evaporation

fractional distillation

polymerisation

Explain your answer.

Method _____

Explanation _____

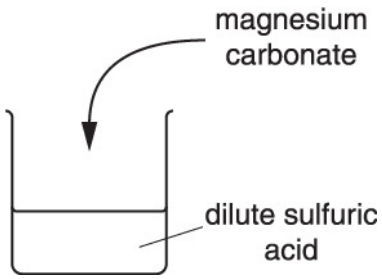
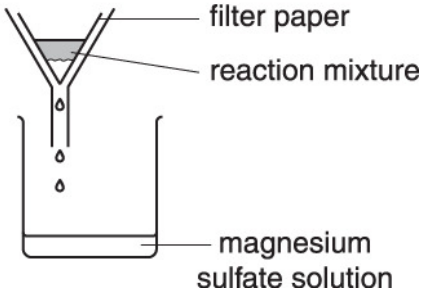
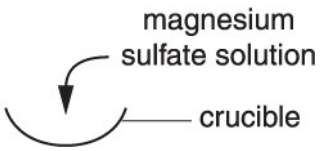
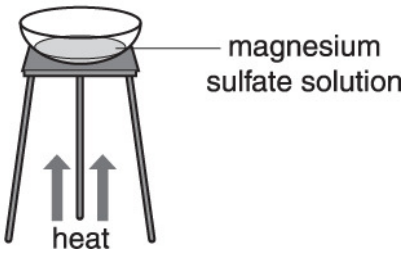
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_____ [2]

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37 Jim makes some magnesium sulfate.

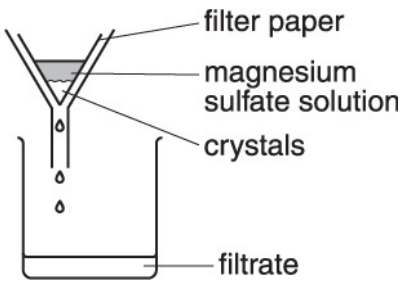
This is the method he uses.

Step **1**  	Jim adds magnesium carbonate to dilute sulfuric acid. He stops adding magnesium carbonate when the mixture stops bubbling.
Step **2**  	Jim filters the reaction mixture to remove excess magnesium carbonate.
Step **3**  	Jim pours the magnesium sulfate solution into a crucible.
Step **4**  	Jim evaporates half of the magnesium sulfate solution. He then leaves the concentrated solution to cool. Crystals are made in the solution.
	Jim filters off the crystals.

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Step **5**  	
Step **6**  	Jim dries the crystals of magnesium sulfate.

Jim predicts he should make **4 g** of magnesium sulfate.

He actually makes **3 g**.

Calculate the **percentage yield** for this reaction and suggest **reasons** why the yield is **less** than 100%.

The quality of written communication will be assessed in your answer to this question.

[6]

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38 Ethanol can also be made by fermentation from glucose.

Write about how fermentation can be used to make ethanol. Include the conditions needed for fermentation and how to get **pure** ethanol from the reaction mixture.



The quality of written communication will be assessed in your answer to this question.

---

[6]

39 Calculate the molar mass of magnesium oxide, MgO.

The relative atomic mass of Mg is 24 and of O is 16.

answer _____ g/mol

[1]

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40 This question is about some of the hydrocarbons found in crude oil.

The table shows some information about four of these hydrocarbons.

Hydrocarbon	Molecular formula	Fraction of crude oil that contains the hydrocarbon	Melting point in °C	Boiling point in °C	Density in g / cm^3
propane	C_3H_8	liquefied petroleum gases	?188	?42	0.002
hexane	C_6H_{14}	petrol	?95	68	0.66
decane	$C_{10}H_{22}$	paraffin	?30	174	0.73
hexadecane	$C_{16}H_{34}$	diesel	18	287	0.77

A mixture of hexane, decane and hexadecane can be separated by fractional distillation.

Explain why. Use ideas about intermolecular forces and information from the table.

--- [3]

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41 R_f values are used to compare the different spots on a chromatogram.

What is the formula used to calculate an R_f value?

A $R_f = \frac{\text{distance travelled by solvent}}{\text{distance travelled by substance}}$

B $R_f = \frac{\text{distance travelled by substance}}{\text{distance travelled by solvent}}$

C $R_f = \frac{\text{distance travelled by stationary phase}}{\text{distance travelled by mobile phase}}$

D $R_f = \frac{\text{distance travelled by solvent}}{\text{distance travelled by mobile phase}}$

Your answer [ ] [1]

42 Paper chromatography can be used to separate the colours in ink.

Water is the solvent used to separate the colours in water soluble ink.

What name is given to the water used in paper chromatography?

A Absorption phase
B Liquid phase
C Mobile phase
D Stationary phase

Your answer [ ] [1]

43 What is the amount, in mol, of 15 g of carbonate ions, CO_3^{2-}?

A 0.18
B 0.25
C 4.0
D 5.6

Your answer [ ] [1]

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44(a) An alloy is a mixture of a metal with one or more other elements.

When lithium is mixed with aluminium it makes an alloy that can be used in aircraft.

Adding different amounts of lithium to the aluminium changes the properties of the alloy.

Alloy	Percentage of lithium (%)	Density (g / cm^3)	Melting point (°C)	Strength (MPa)
A	2.00	2.58	670	550
B	2.20	2.56	580	555
C	2.45	2.55	655	565

A scientist thinks that alloy **C** is best for making an aircraft.

Is she correct?

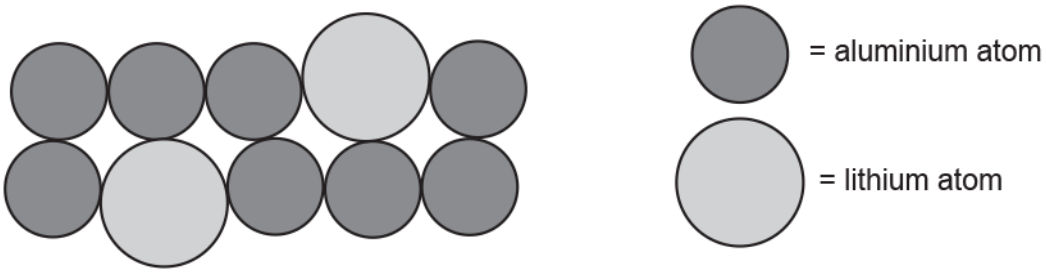
Explain your answer using evidence from the table.

---

[2]

(b) The scientist uses the particle model to show the elements present in alloy **B**.

Look at her diagram.



Alloy **B**

not to scale

(i) Calculate the **percentage of lithium atoms** in the diagram of alloy **B**.

Percentage of lithium atoms = ... % **[1]**

(ii) Use your answer to part **(i)** to explain if the diagram accurately shows the structure of alloy **B**.

---

[1]

45 Simple distillation can be used to separate mixtures of liquids.

A scientist is using simple distillation to separate a mixture of alcohols.

Look at the table. It shows the boiling points of three alcohols.

Alcohol	Boiling point (°C)
Methanol	65
Ethanol	78
Propanol	97

(i) Which alcohol will be distilled first?

Tick (✓) **one** box.

Methanol ☐

Ethanol ☐

Propanol ☐

Explain your answer.

---

[2]

(ii) Simple distillation uses evaporation and condensation to separate mixtures.

$$\text{ethanol (l)} \underset{\text{condensation}}{\overset{\text{evaporation}}{\rightleftharpoons}} \text{ethanol (g)}$$

Describe the change in the **arrangement** of particles as substances evaporate.

---

[1]

(iii) Describe the change in the **movement** of particles as substances evaporate.

---

[1]

(iv) The scientist wants to improve the separation of the mixture of alcohols.

Suggest a piece of equipment he could use.

Explain how this will improve the separation of the mixture of alcohols.

---

[2]

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46 The formula of sulfuric acid is H_2SO_4.

What is the **relative formula mass**, M_r, of sulfuric acid?

The relative atomic mass, A_r, of H is 1, of S is 32 and of O is 16.

A 49

B 98

C 130

D 200

Your answer ☐ **[1]**

47 The molecular formula of hydrogen peroxide is H_2O_2.

What is the **empirical formula** of hydrogen peroxide?

A H_2O_2

B H_2O

C HO

D H_2O_4

Your answer ☐ **[1]**

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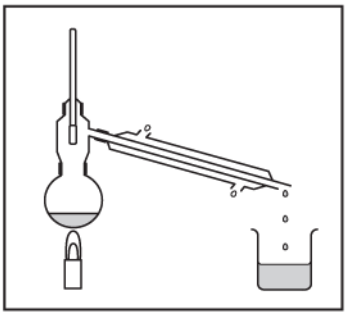
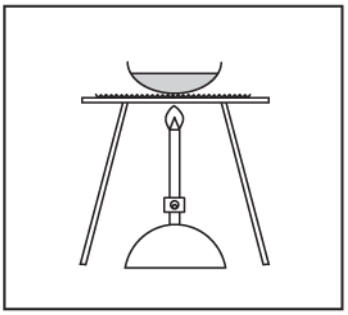
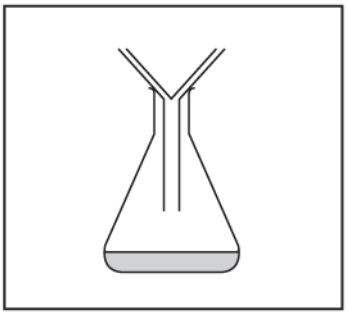
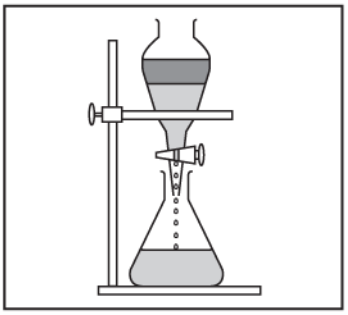
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48(a) Different mixtures can be separated using different methods.

Draw a line from each **separation process** to the **apparatus used**.

Use only **one** line for each process.

Separation process	Apparatus used
Crystallisation	
Filtration	
Distillation	
	

[3]

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(b) A student is given a mixture of iron filings and sulfur powder.

Suggest a method that he could use to separate the iron and sulfur.

---

[1]

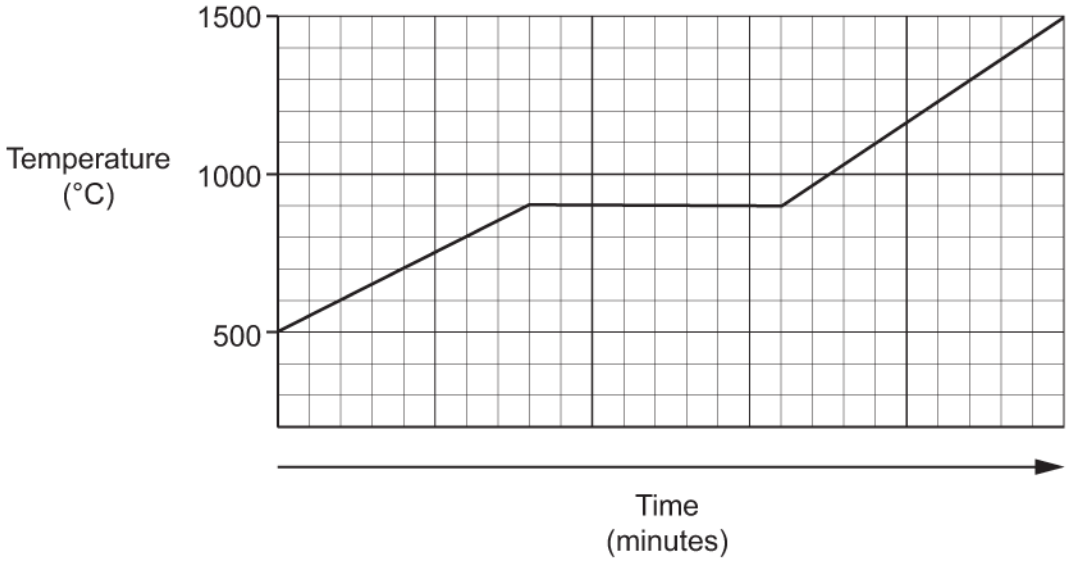
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49 A new solid, compound **X**, has been discovered. Scientists investigated the effect of heat on compound **X**.

Look at the graph. It shows how the state of compound **X** changes as it is heated.



(i) What is the **melting point** of compound **X**?

Melting point = ... °C **[1]**

(ii) A scientist describes compound **X** as a **pure** substance.

Explain what scientists mean when they describe compounds as pure.

---

[1]

(iii) Explain how the scientists tell from the graph that compound **X** is a pure substance.

---

[1]

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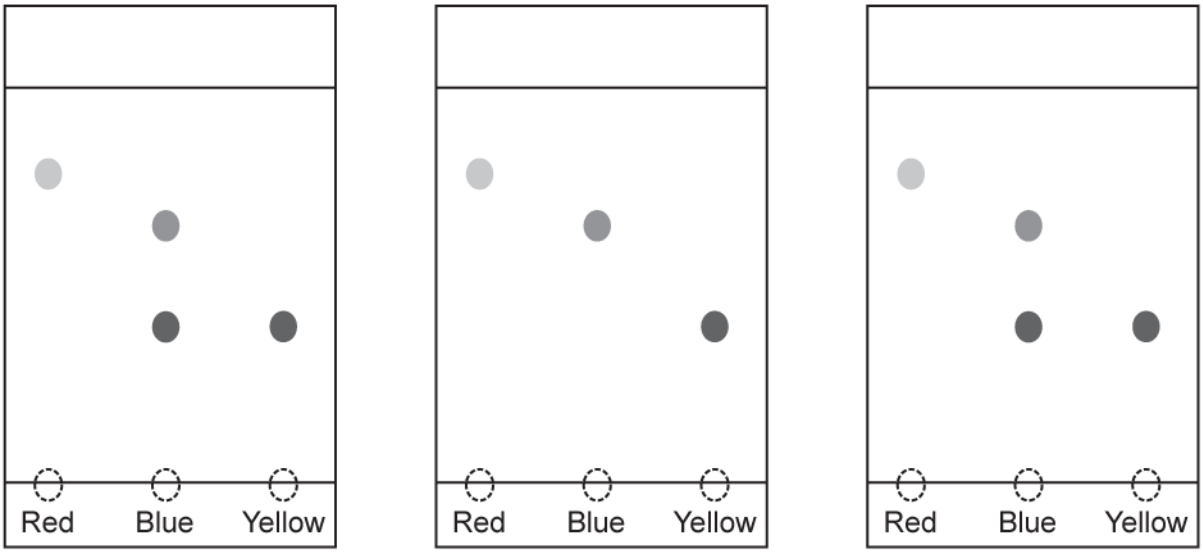
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50(a) A painting has arrived at a local museum for a new exhibit.

To make sure the painting is genuine, a sample of the paints from the painting is sent to a laboratory for analysis.

The laboratory uses thin-layer chromatography to compare the sample of the paints from the painting with some paints used in 1849 and 1973.

The chromatograms are shown below.



Sample of the paints from the painting | **Paints used in 1849** | **Paints used in 1973**

(i) Look at the chromatogram for the sample of the paints from the painting.

Which paint colour(s) is/are **pure**?

---

[1]

(ii) The red, blue and yellow paint from the painting are dissolved in different solvents, **X**, **Y** and **Z**.

The results are shown below.

		Solvent used		
		X	Y	Z
Paint colour	Red	Red solid left in tube	Clear red solution	Clear red solution
	Blue	Blue solid left in tube	Clear blue solution	Clear blue solution
	Yellow	Yellow solid left in tube	Clear yellow solution	Yellow solution with some yellow solid left in tube

Which solvent, **X**, **Y** or **Z**, should the laboratory use for the thin-layer chromatography?

Explain why this would be better than the other solvents.

---

[2]

(iii) Scientists use R_f values to compare the different spots on the chromatogram.

Calculate the R_f value for the **red paint** in the sample of paints from the painting.

Use the equation: $R_f = \frac{\text{distance travelled by the substance}}{\text{distance travelled by the solvent}}$

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

R_f = ... **[3]**

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(b) The laboratory think that the painting was completed in 1849.

Is the laboratory correct?

Explain your answer.

---

[1]

51(a) An alloy is a mixture of a metal with one or more other elements.

When lithium is mixed with aluminium it makes an alloy that can be used in aircraft.

Adding different amounts of lithium to the aluminium changes the properties of the alloy.

Alloy	Percentage of lithium (%)	Density (g / cm^3)	Melting point (°C)	Strength (MPa)
A	2.00	2.58	670	550
B	2.20	2.56	580	555
C	2.45	2.55	655	565

A scientist thinks that alloy **C** is best for making an aircraft.

Is she correct?

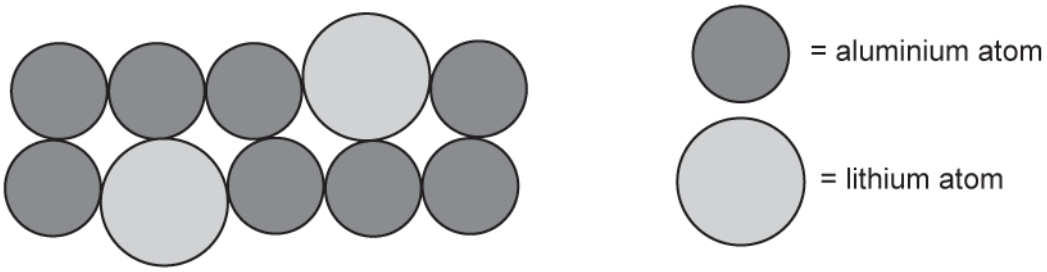
Explain your answer using evidence from the table.

---

[2]

(b) The scientist uses the particle model to show the elements present in alloy **B**.

Look at her diagram.



Alloy **B**

not to scalse

(i) Calculate the **percentage of lithium atoms** in the diagram of alloy **B**.

Percentage of lithium atoms = ... % **[1]**

(ii) Use your answer to part **(c)(i)** to explain if the diagram accurately shows the structure of alloy **B**.

---

[1]

52 Which separation technique is this equipment used for?



A Crystallisation
B Distillation
C Evaporation
D Filtration

Your answer ☐ [1]

53 The formula of magnesium chloride is $MgCl_2$.

What is the relative formula mass of magnesium chloride?

(A_r: Mg = 24.3, Cl = 35.5)

A 59.8
B 95.3
C 119.6
D 84.1

Your answer ☐ [1]

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54 Butane has the molecular formula C_4H_{10}.

What is the **empirical** formula of butane?

A CH_5

B C_2H_5

C C_4H_{10}

D CH_{14}

Your answer ☐ [1]

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55(a) The table shows the properties of different substances.

Substance	Melting point (°C)	Boiling point (°C)	Soluble in water?	Conducts electricity in solid state?	Conducts electricity in molten state?
A	–210	–196	No	No	No
B	1084	2562	No	Yes	Yes
C	605	1137	Yes	No	Yes
D	–78	–34	Yes	No	No

(i) Which **two** substances are gases at room temperature?

Tick (✓) **two** boxes.

A ☐

B ☐

C ☐

D ☐

[1]

(ii) Substance **C** is an ionic substance.

Use the information in the table to explain why.

---

[2]

(b) You are provided with a mixture of substances **B** and **C**.

Substance **B** is insoluble in water. Substance **C** is soluble in water.

(i) Describe how you could separate substance **B** from the mixture.

---

[3]

(ii) Describe how you would then obtain substance **C** after separating substance **B**.

---

[2]

56 * Potassium chloride is a mineral found in many foods.

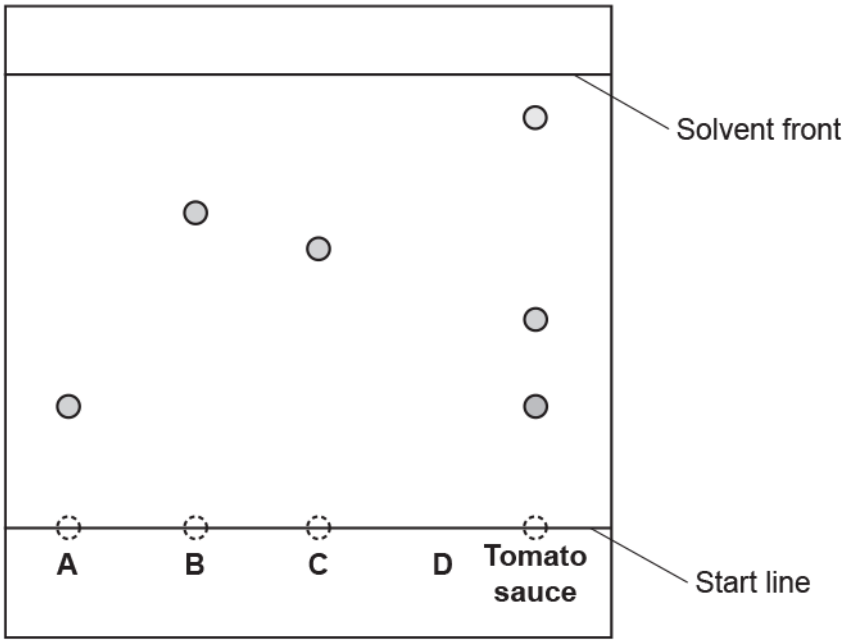
A student wants to make a salt called potassium chloride, KC*l*, by neutralisation of an acid by an alkali.

Describe how to make a pure, dry sample of potassium chloride in a laboratory by neutralisation.

[6]

57(a) A scientist analyses a sample of tomato sauce using chromatography.

The tomato sauce is compared to four known food additives, **A**, **B**, **C** and **D**, as shown in the chromatogram.



The start line is **not** drawn in ink.

Explain why.

---

[1]

(b) Food additive **D** is insoluble in the solvent used.

Draw on the diagram the spot for food additive **D** at the end of the experiment. **[1]**

(c) Which additive is in the **tomato sauce**?

Tick (✓) **one** box.

A ☐

B ☐

C ☐

[1]

(d) Calculate the R_f value for additive **C**.

Use the equation: $R_f = \frac{\text{distance travelled by the substance}}{\text{distance travelled by the solvent}}$

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

R_f value = ... **[3]**

58(a) A student is making perfume using violet flowers.

The student does an experiment to extract the perfume from the flowers using the apparatus shown in **Fig. 21.1**.

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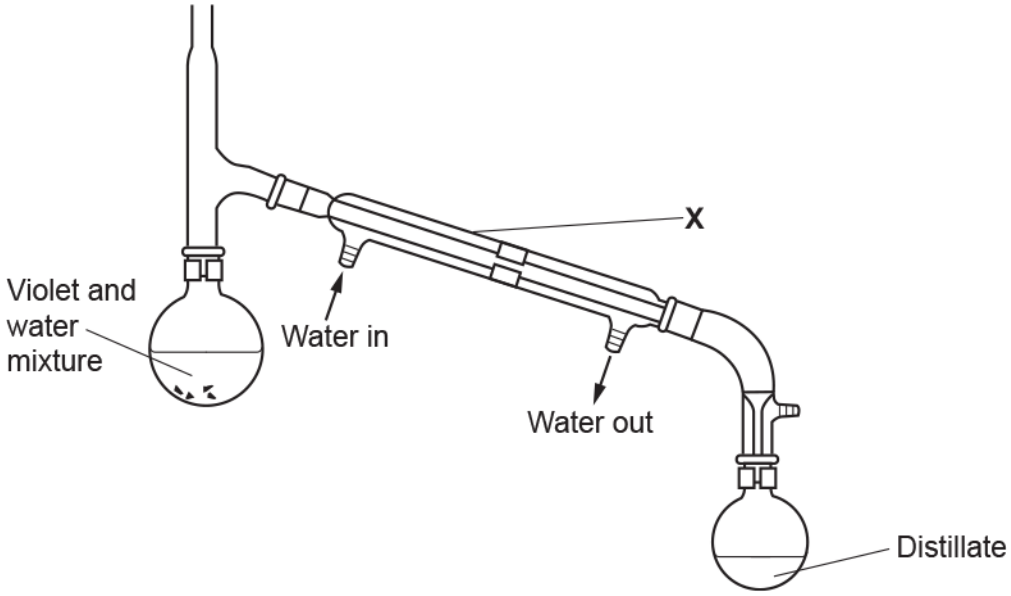


Fig. 21.1

The teacher says the apparatus is not set-up correctly.

(i) What is the name of the piece of apparatus labelled **X**?

[1]

(ii) Name the process shown in **Fig. 21.1**.

[1]

(iii) Suggest **two** changes that the student should make to set-up the apparatus correctly.

1

2

[2]

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(b) The student finds out that phosphate fertilisers are used to help to grow flowers.

Compound **A** is a fertiliser of a metal **M** with the formula $\mathbf{M}_3PO_4$.

The relative formula mass of compound **A** is 164.0.

Do a calculation to identify metal **M**.

Use the relative atomic masses in the Periodic Table.

Metal **M** = ... **[3]**

59 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

Your answer ☐ **[1]**

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

A Chromatography
B Distillation
C Evaporation
D Filtration

Your answer ☐ **[1]**

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61 The accurate relative atomic mass of aluminium is 26.9815385.

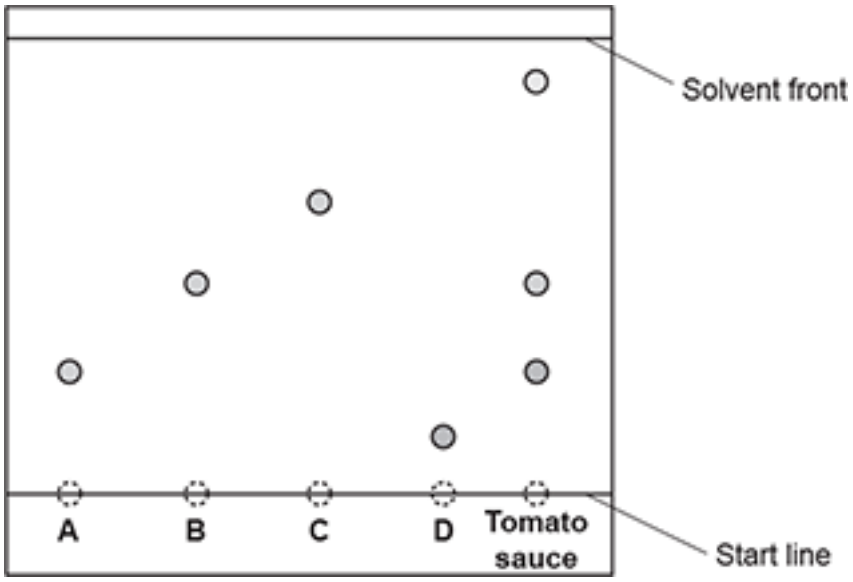
What is this number to **5** significant figures?

A 26.98153
B 26.981
C 26.98154
D 26.982

Your answer [1]

62(a) A student analyses a sample of tomato sauce using thin-layer chromatography.

The tomato sauce was compared to four known food additives, **A**, **B**, **C** and **D**, as shown in the chromatogram.



(i) Calculate the R_f value for **C**.

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

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R_f value = ... **[3]**

(ii) Which additives are shown to be in the tomato sauce?

Tick (✓) **all the correct** boxes.

A ☐

B ☐

C ☐

D ☐

[1]

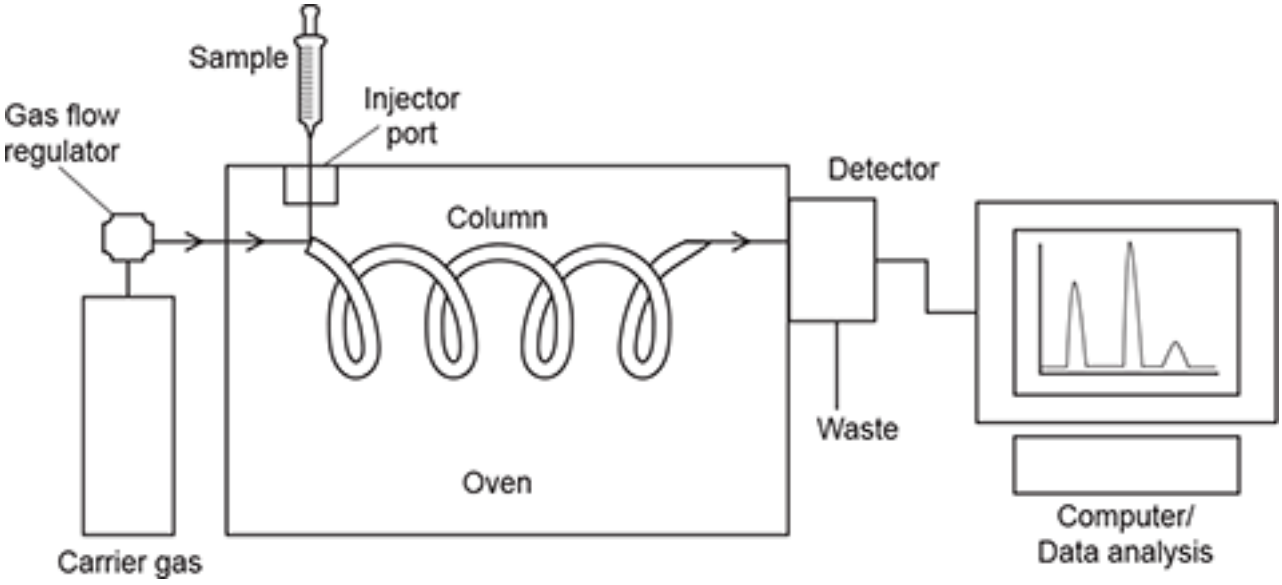
(iii) Suggest why **D** has **not** travelled as far up the plate as **C**.

---

[1]

(b) Gas chromatography is another type of chromatography.

The diagram shows the equipment used for gas chromatography.



(i) State **one similarity** and **one difference** between gas chromatography and thin-layer chromatography.

Similarity ----------

Difference ----------

---

[2]

(ii) Explain why thin-layer chromatography is used instead of gas chromatography to analyse the tomato sauce.

---

[1]

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63 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]**

64 Ammonium nitrate, NH_4NO_3, is fertiliser made from ammonia.

Ammonium nitrate is made by reacting ammonia with nitric acid.

$NH_3 + HNO_3 \rightarrow NH_4NO_3$

(i) Calculate the mass of **ammonium nitrate** that could be made from 25.5 tonnes of ammonia.

A_r: H = 1.0, N = 14.0, O = 16.0

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Mass of ammonium nitrate = ... tonnes **[3]**

(i) A student makes some ammonium nitrate in the laboratory.

He predicts that he should make 12.5 g of ammonium nitrate.

His percentage yield is 80%.

Calculate the **actual mass** of ammonium nitrate that the student makes.

Actual mass of ammonium nitrate = ... g **[2]**

65 Ammonium nitrate, NH_4NO_3, is a fertiliser made from ammonia.

Ammonium nitrate is made by reacting ammonia with nitric acid.

$NH_3 + HNO_3 \rightarrow NH_4NO_3$

(i) Calculate the mass of **ammonium nitrate** that could be made from 25.5 tonnes of ammonia.

A_r: H = 1.0, N = 14.0, O = 16.0

Mass of ammonium nitrate = ... tonnes **[3]**

(ii) A student makes some ammonium nitrate in the laboratory.

He predicts that he should make 12.5 g of ammonium nitrate.

His percentage yield is 80%.

Calculate the **actual mass** of ammonium nitrate that the student makes.

Actual mass of ammonium nitrate ..... g **[2]**

END OF QUESTION PAPER