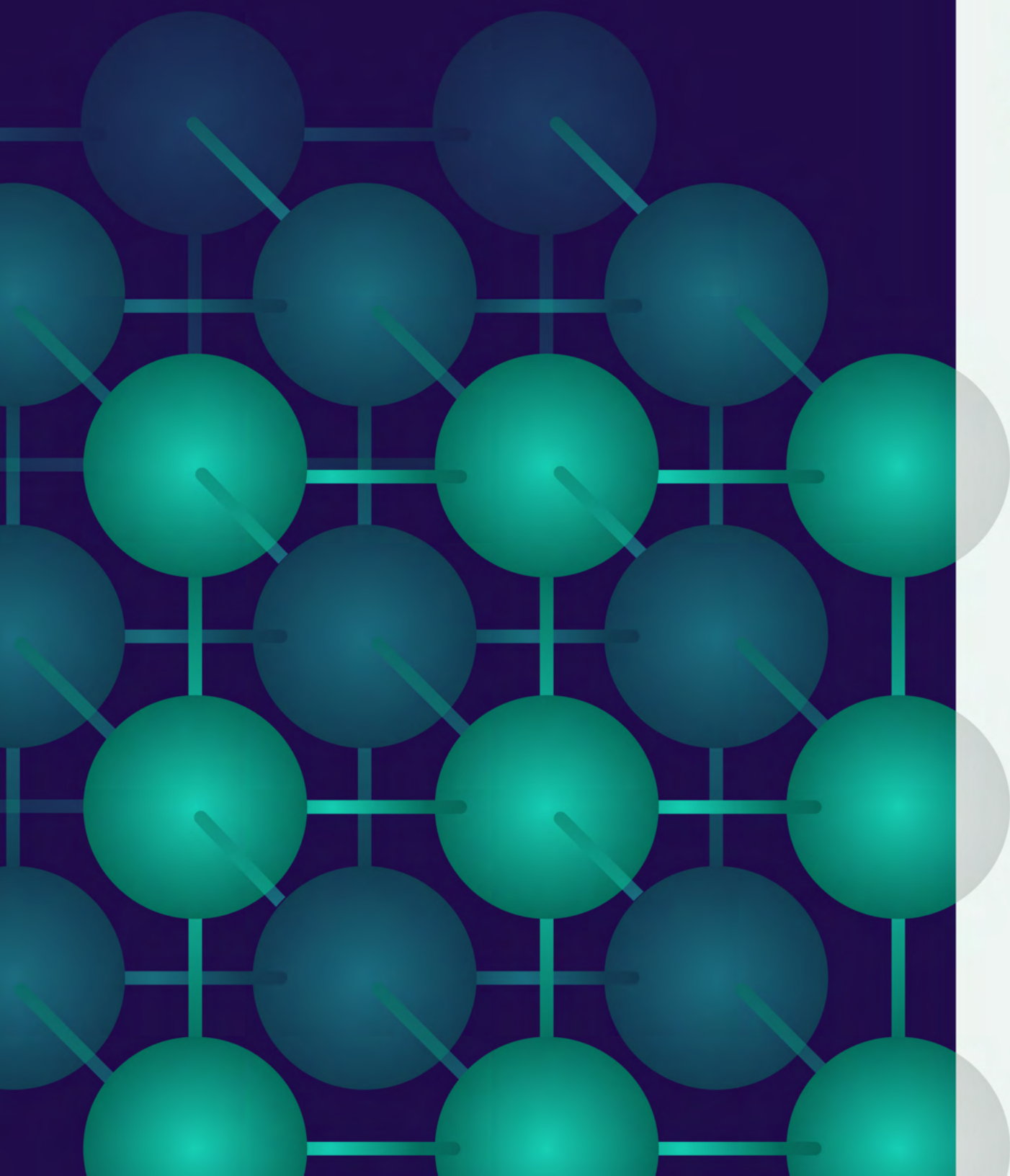


Sparx Science

A Level Transition Booklet



Chemistry



This booklet contains questions from key topics that you will have seen in GCSE and that contain the key knowledge and skills for you to be successful in your AS Level and A-Levels.

If you have access to Sparx Science, you can also use the topic codes (the codes starting with a Z or and R) to access even more questions which come with targeted support. Simply search the topic codes on your Independent Learning page.

Below is a summary of the topics included in this booklet for you to keep track of your learning.

	Topic	Introduction	Pages	Complete?
1	Atomic structure	All substances are made of atoms. In this section, we recap the subatomic particles and how they are arranged in our modern model of the atom.	4 - 12	
2	The Periodic Table	The Periodic Table organises all the known elements to help chemists understand their properties. In this section, we recap the organisation of elements and trends across the Periodic Table.	13 - 18	
3	Chemical equations	Chemical equations allow chemists to show how substances change during chemical reactions. This section revisits writing and balancing different types of equations, including ionic equations.	19 - 23	
4	Quantitative Chemistry	Quantitative Chemistry uses measurements and calculations to determine the amounts of substances involved in chemical reactions. This section recaps key calculations to work out masses, moles and concentrations.	24 - 33	
5	Bonding and properties of materials	Theories of structure and bonding help to explain the physical and chemical properties of materials. Here, we cover models for different types of bonding including covalent, ionic and metallic bonding.	34 - 51	
6	Energy and kinetics	Energetics and kinetics is the study of energy changes during reactions and how quickly reactions occur. In this section, we look at how energy is transferred in reactions and how we can represent and measure those transfers.	52 - 73	
7	Acids and bases	The study of acids and bases involves investigating their properties, how they react, and how their strength and concentration can be measured. In this section, we recap these key principles.	74 - 77	
8	Organic Chemistry	Organic chemistry looks at covalent compounds containing the element carbon. In this section, you recap simple carbon compounds as well as some of the effects that burning carbon compounds can have on the environment.	78 - 82	
9	Experimental techniques	Chemists use a wide variety of techniques to analyse chemicals. In this section, you look at a few common techniques for analysing mixtures.	83 - 85	

Sparx Science

1		2																				3		4		5		6		7		0	
(18)																																	
1.0 H Hydrogen 1																																	
(1)	(2)	Atomic symbol Name Relative atomic mass Atomic (proton) number																		(13)	(14)	(15)	(16)	(17)	4.0 He Helium 2								
6.9 Li Lithium 3	9.0 Be Beryllium 4																			10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10								
23.0 Na Sodium 11	24.3 Mg Magnesium 12																			27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	39.9 Ar Argon 18								
39.1 K Potassium 19	40.1 Ca Calcium 20	45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30	69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36																
85.5 Rb Rubidium 37	87.6 Sr Strontium 38	88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	96.0 Mo Molybdenum 42	[97] Tc Technetium 43	101.1 Ru Ruthenium 44	102.9 Rh Rhodium 45	106.4 Pd Palladium 46	107.9 Ag Silver 47	112.4 Cd Cadmium 48	114.8 In Indium 49	118.7 Sn Tin 50	121.8 Sb Antimony 51	127.6 Te Tellurium 52	126.9 I Iodine 53	131.3 Xe Xenon 54																
132.9 Cs Caesium 55	137.3 Ba Barium 56	138.9 La * Lanthanum 57	178.5 Hf Hafnium 72	180.9 Ta Tantalum 73	183.8 W Tungsten 74	186.2 Re Rhenium 75	190.2 Os Osmium 76	192.2 Ir Iridium 77	195.1 Pt Platinum 78	197.0 Au Gold 79	200.6 Hg Mercury 80	204.4 Tl Thallium 81	207.2 Pb Lead 82	209.0 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	[267] Rf Rutherfordium 104	[270] Db Dubnium 105	[269] Sg Seaborgium 106	[270] Bh Bohrium 107	[270] Hs Hassium 108	[278] Mt Meitnerium 109	[281] Ds Darmstadtium 110	[281] Rg Roentgenium 111	[285] Cn Copernicium 112	[286] Nh Nihonium 113	[289] Fl Flerovium 114	[289] Mc Moscovium 115	[293] Lv Livermorium 116	[294] Ts Tennessine 117	[294] Og Oganesson 118																
* Lanthanides																																	
† Actinides																																	
140.1 Ce Cerium 58	140.9 Pr Praseodymium 59	144.2 Nd Neodymium 60	[145] Pm Promethium 61	150.4 Sm Samarium 62	152.0 Eu Europium 63	157.3 Gd Gadolinium 64	158.9 Tb Terbium 65	162.5 Dy Dysprosium 66	164.9 Ho Holmium 67	167.3 Er Erbium 68	168.9 Tm Thulium 69	173.0 Yb Ytterbium 70	175.0 Lu Lutetium 71																				
232.0 Th Thorium 90	231.0 Pa Protactinium 91	238.0 U Uranium 92	[237] Np Neptunium 93	[244] Pu Plutonium 94	[243] Am Americium 95	[247] Cm Curium 96	[247] Bk Berkelium 97	[251] Cf Californium 98	[252] Es Einsteinium 99	[257] Fm Fermium 100	[258] Md Mendelevium 101	[259] No Nobelium 102	[262] Lr Lawrencium 103																				

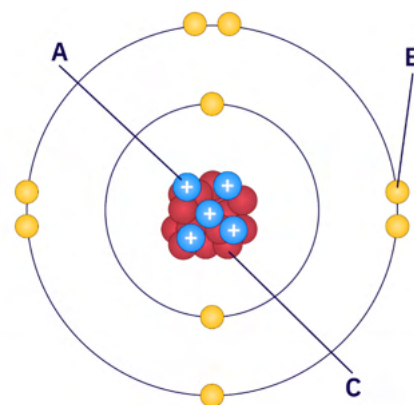
1.1

This diagram shows the structure of the atom.
Name the subatomic particle shown by each label.

A:

B:

C:



1.2

Tick one box in each row of the table to give the charge of each subatomic particle.

Particle	Charge				
	-2	-1	0	+1	+2
Electron					
Proton					
Neutron					

1.3

Tick one box in each row of the table to show the relative mass of each subatomic particle.

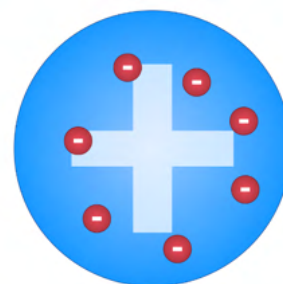
Subatomic particle	Relative mass			
	-1	0	$\frac{1}{1836}$	1
Electron				
Proton				
Neutron				

1.4 Where is most of the mass of the atom concentrated?

.....

.....

1.5 JJ Thomson thought that atoms were positive spheres, with small negative charges in them. He called this model the '**plum pudding model**'. Give **one** way in which this model is



a) **different** to the current model of the atom.

.....

.....

b) **similar** to the current model of the atom.

.....

.....

Atomic number and mass number

R646

2.1 What does the atomic number tell you?

The number of neutrons
in the nucleus

The number of protons in
the nucleus

The number of electron
shells

The number of electrons
in the outer shell

2.2

This shows sodium as it appears on the Periodic Table.
Describe what each letter represents.

a) X

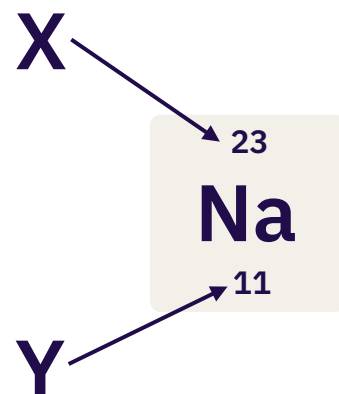
.....

.....

b) Y

.....

.....



2.3

Use the Periodic Table to answer these questions about **aluminium**.

a) How many **protons** does an atom of aluminium contain?

.....

b) How many **neutrons** does an atom of aluminium contain?

.....

2.4

Look at **potassium** on the Periodic Table.

Identify how many of each subatomic particle are in an atom of potassium.

number of protons:

number of electrons:

number of neutrons:

- 2.5** Look at the elements below.
Which elements contain equal numbers of protons and neutrons?
Tick **all** that apply.



- 2.6** The mass number and atomic number of an atom are equal.
Suggest what this tells us about the subatomic particles in the atom.

.....

.....

Isotopes

R889

- 3.1** Two isotopes of potassium are:
- potassium-39 (${}^{39}_{19}\text{K}$)
 - potassium-40 (${}^{40}_{19}\text{K}$).
- Describe what is meant by the term "isotopes".

.....

.....

.....

.....

- 3.2** Two isotopes of an unknown element, ?, are:



Use the Periodic Table to name the element.

.....

3.3 Two isotopes of tin are tin-112 ($^{112}_{50}\text{Sn}$) and tin-119 ($^{119}_{50}\text{Sn}$).

How many more neutrons are in the nucleus of a tin-119 atom than a tin-112 atom?

.....

3.4 Uranium-235 ($^{235}_{92}\text{U}$) is an isotope of uranium.

Isotope	Atomic number	Mass number
A	92	238
B	94	238
C	92	234

a) Which isotope shown in the table is not an isotope of uranium?

.....

b) Give a reason for your answer.

.....

.....

3.5 Two isotopes of lead are $^{204}_{82}\text{Pb}$ and $^{206}_{82}\text{Pb}$.

Explain how you can tell these are isotopes.

.....

.....

.....

.....

3.6

Potassium has three naturally occurring isotopes:

- potassium-39
- potassium-40
- potassium-41

Suggest why the isotopes have similar chemical properties, despite having different atomic structures.

.....

.....

Calculations involving isotopes

Z821

4.1

Rubidium has two isotopes.

The table shows the mass numbers and percentage abundances of the isotopes.

Mass number	Percentage abundance (%)
85	72
87	28

Calculate the relative atomic mass of rubidium.

.....

4.2

Silicon has three isotopes:

- 92.2% silicon-28
- 4.7% silicon-29
- 3.1% silicon-30

Calculate the relative atomic mass of silicon.

.....

4.3

Chromium, Cr, has four isotopes.

Isotope	Relative mass of isotope	Percentage abundance
^{50}Cr	50	4.3
^{52}Cr	52	83.8
^{53}Cr	53	9.5
^{54}Cr	54	2.4

Calculate the relative atomic mass of chromium to 1 decimal place.

.....

4.4

Element R has three isotopes.

The table shows the mass numbers and percentage abundances of the isotopes.

One of the percentages is missing.

Mass number	Percentage abundance (%)
39	93.26
40	0.01
41	?

Calculate the relative atomic mass of element R to 2 decimal places.

.....

4.5

Element J has three isotopes.

The relative abundances and mass numbers of the isotopes are shown.

Mass number	Relative abundance
28	30.74
29	1.56
30	1.03

Calculate the relative atomic mass of J.

Give your answer to one decimal place.

.....

4.6

Neon has a relative atomic mass of 20.19

It has three isotopes.

Mass number	Percentage abundance (%)
20	90.5
21	0.3

Calculate the mass number and percentage abundance of the third isotope.

Give the mass number to the nearest whole number.

Mass number:

Percentage abundance:%

5.1 An atom of an element has electron configuration 2,8,6.

a) How many electrons does it have in total?

.....

b) How many electron shells does it have?

.....

5.2 Name the element that has the electron configuration 2,4.

.....

5.3 Write the electron configuration for an atom of neon.

.....

5.4 Which of the following electron configurations correspond to elements in

a) Group 3? Tick **all** that apply.

2, 1 ☐

2, 3 ☐

2, 8, 1 ☐

2, 8, 3 ☐

2, 8, 7 ☐

b) Period 3? Tick **all** that apply.

2, 1 ☐

2, 3 ☐

2, 8, 1 ☐

2, 8, 3 ☐

2, 8, 7 ☐

5.5 Calcium reacts to lose 2 electrons, forming Ca^{2+} ions.

How many electron shells does a Ca^{2+} ion have?

.....

- 1.1** These are key terms used when talking about the Periodic Table.
Match each term to the correct definition.

Key term

Period

Group

Definition

The columns in the Periodic Table

The rows in the Periodic Table

The area in the Periodic Table where metals are found

The area in the Periodic Table where non-metals are found

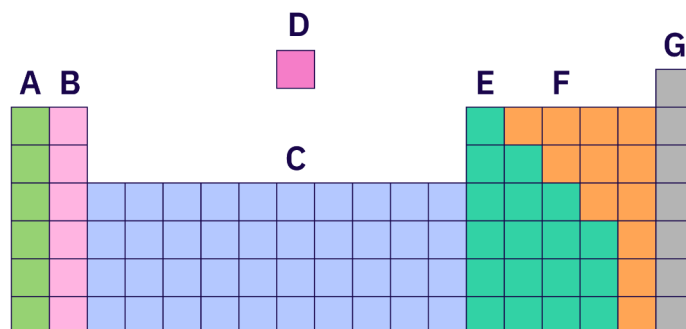
- 1.2** How are elements arranged in the modern Periodic Table?

.....

.....

- 1.3** The diagram shows a version of the Periodic Table.

Tick one box in each row of the table to show whether the elements in sections A to G are likely to be metals or non-metals.



	Metals	Non-metals
A		
B		
C		
D		
E		
F		
G		

2. The Periodic Table

- 1.4** Elements in the same group of the Periodic Table have similar chemical properties. Why is this?

.....

.....

- 1.5** Potassium (K) and sodium (Na) are both alkali metals. Use the Periodic Table to give **one** difference and **one** similarity between the electronic configurations of these two metals.

.....

.....

.....

.....

Alkali metals

R925, R406

- 2.1** The melting points of some Group 1 metals are shown.

Element	Melting point (°C)
Sodium	98
Potassium	63

Use the information in the table to choose which option below is most likely to be the melting point of

a) rubidium.

40°C ☐ 63°C ☐ 80°C ☐ 98°C ☐ 180°C ☐

b) lithium.

40°C ☐ 63°C ☐ 80°C ☐ 98°C ☐ 180°C ☐

- 2.2** The radius of an atom is the distance between its nucleus and the outer electron shell.
Which of the following is true of the radius of the atoms as you go down Group 1?

It increases

☐

It decreases

☐

It increases then decreases

☐

There is no trend

☐

- 2.3** Which of the following describes what happens to the reactivity of alkali metals as the atomic radius increases?

The reactivity increases

☐

The reactivity increases then decreases

☐

The reactivity decreases

☐

The reactivity decreases then increases

☐

- 2.4** Explain why the reactivity of alkali metals increases down Group 1.

.....

.....

.....

.....

.....

.....

- 3.1** There are certain trends in the halogens as you go down the group. Tick one box in each row of the table to show what happens to the following properties as you go down Group 7.

	Change down the group		
	Increases	Decreases	Stays constant
Boiling point			
Melting point			
Relative atomic mass			

- 3.2** The table shows the boiling points of some elements in Group 7.

Element	Boiling point (°C)
Fluorine	-188
Chlorine	-35
Bromine	58

Iodine is below bromine in Group 7.
Predict the boiling point of iodine.

.....°C

- 3.3** Astatine is just below iodine in the Periodic Table. Astatine is so rare and unstable that many of its properties are actually estimated. Tick one box in each row of the table to show how you would expect the properties of astatine to compare to iodine.

	Element	
	Astatine	Iodine
The element that forms molecules with a higher relative molecular mass		
The element that has a higher melting point		
The element that has a higher boiling point		

3.4

Look at this reaction:



a) Give the name of the type of reaction shown.

.....

b) Which of the halogens present in the reaction is more reactive?

.....

3.5

Look at the pairs of reactants in the table.

Tick one box in each row to show whether each pair of reactants will result in a reaction or not.

Reactants	Reaction	No reaction
bromine + lithium chloride		
bromine + lithium iodide		
chlorine + sodium iodide		

3.6

Chlorine can displace iodine from a salt as chlorine is more reactive.

By referring to their atomic structures, explain why chlorine is more reactive than iodine.

.....

.....

.....

.....

3.7

X, Y and Z represent three different halogens.

Some reactions of these halogens are shown.

- $2\text{KX}(\text{aq}) + \text{Y}_2(\text{aq}) \rightarrow 2\text{KY}(\text{aq}) + \text{X}_2(\text{aq})$
- $2\text{KX}(\text{aq}) + \text{Z}_2(\text{aq}) \rightarrow 2\text{KZ}(\text{aq}) + \text{X}_2(\text{aq})$
- $2\text{KY}(\text{aq}) + \text{Z}_2(\text{aq}) \rightarrow \text{no reaction}$

Use this information to sort X, Y and Z in order of increasing reactivity.

Least reactive



Most reactive

.....

.....

.....

1.1

Here is the word equation for a chemical reaction:



Tick one box in each row of the table to show whether each substance is a reactant or a product.

	Reactant	Product
Sodium bromide		
Chlorine		
Sodium chloride		
Bromine		

1.2

Magnesium reacts with oxygen to form magnesium oxide.

Write the word equation for this reaction.

.....

1.3

A scientist adds a solution of potassium iodide to a solution of lead nitrate.

A yellow precipitate of lead iodide forms.

Potassium nitrate remains dissolved in the solution.

Complete the word equation for this reaction by writing the correct state symbols.

potassium iodide (.....) + lead nitrate (.....) → lead iodide (.....) + potassium nitrate (.....)

1.4

Write the missing element in to complete the following word equation:

..... + oxygen → copper oxide

3. Chemical equations

1.5

Look at these four word equations:

A. magnesium(s) + sulfuric acid(aq) → magnesium sulfate(aq) + hydrogen(g)

B. sodium(s) + chlorine(g) → sodium chloride(s)

C. ethane(g) + oxygen(g) → carbon dioxide(g) + water(l)

D. hydrogen peroxide(aq) $\xrightarrow{\text{manganese dioxide}}$ water(l) + oxygen(g)

Tick boxes in each row of the table to show which equation each statement applies to.

You may tick more than one box per row.

	Equation			
	A	B	C	D
Has a gaseous product				
Involves a catalyst				
Has more reactants than products				
Has no solid reactants				

Balancing chemical equations

R994

2.1

Look at this equation:



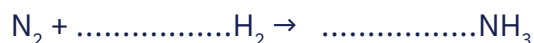
How many moles of each substance is needed to balance the equation?

CH₄ = O₂ = CO₂ = H₂O =

2.2

This equation shows the reaction that produces ammonia.

Write in the correct coefficients to balance the equation.



2.3

This equation shows a reaction to produce iron metal.

Write in the correct coefficients to balance the equation.

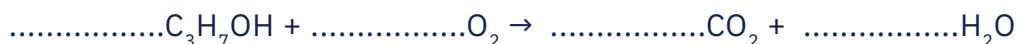


3. Chemical equations

- 2.4** This reaction shows the complete combustion of ethanol.
Write in the correct coefficients to balance the equation.



- 2.5** This reaction shows the complete combustion of propanol.
Write in the correct coefficients to balance the equation.



Redox reactions

R245

- 3.1** a) Draw lines to match each term to its definition.

Term	Definition
	Loss of electrons
Reduction	Loss of protons
Oxidation	Gain of electrons
	Gain of protons

- b) What term describes a reaction where oxidation and reduction both occur?

.....

- 3.2** Copper can displace silver from a solution of silver nitrate.



Describe what is happening in terms of electrons during this displacement.

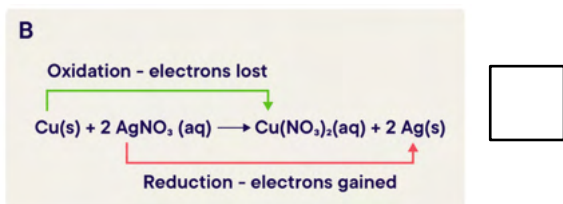
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.....

.....

3. Chemical equations

- 3.3** Copper can displace silver from silver nitrate solution.
This is also a redox reaction.
Which equation correctly shows the redox reaction?



Ionic equations

R671

- 4.1** During a reaction, oxide ions lose electrons and form oxygen molecules.
Balance the half equation to show this reaction.



- 4.2** In the test for chloride ions, silver nitrate solution is added to a sample solution.
A white precipitate of silver chloride forms.
Complete the ionic equation for this reaction.



- 4.3** Zinc chloride is produced during a displacement reaction between zinc and copper chloride solution.
The equation for the reaction is: **$\text{Zn} + \text{CuCl}_2 \rightarrow \text{ZnCl}_2 + \text{Cu}$**
Complete the ionic equation for this reaction.



- 4.4** This equation shows the neutralisation reaction between nitric acid and sodium hydroxide.
 $\text{HNO}_3(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{NaNO}_3(\text{aq}) + \text{H}_2\text{O(l)}$
Write the ionic equation for this reaction.

.....

3. Chemical equations

4.5

Look at the balanced symbol equation for the displacement reaction between iron and lead nitrate:



a) Write a balanced half equation for the oxidation of iron.

.....

b) Write a balanced half equation for the reduction of lead ions.

.....

4.6

When zinc metal is added to copper sulfate solution, copper metal is displaced. This redox reaction can be shown with two half equations:



Complete the table to show which half equation each statement describes.

	Half equation	
	$\text{Zn}(\text{s}) \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{e}^-$	$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$
Shows oxidation		
Shows reduction		
Shows the gain of electrons		

4.7

Magnesium metal reacts with silver ions to form magnesium ions and silver metal. Write the two half equations for this reaction.

Half equation 1:

Half equation 2:

- 1.1** Calculate the relative formula mass of calcium carbonate, CaCO_3 .
Relative atomic masses: C = 12, O = 16, Ca = 40

.....

- 1.2** Calculate the relative formula mass of sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.
Relative atomic masses: O = 16, Na = 23, S = 32

.....

- 1.3** A metal carbonate was known to have the formula M_2CO_3 , where M represents the atomic symbol of an unknown metal.
 M_2CO_3 has a relative formula mass of 106.

a) Calculate the relative atomic mass of metal M.

.....

b) Therefore, name metal M.

.....

- 2.1** Calculate the percentage by mass of sodium in sodium chloride.
Give your answer to 1 decimal place.
Relative atomic masses: Na = 23, Cl = 35.5

.....%

- 2.2** Which of these substances is 75% carbon by mass?
Relative atomic masses: C = 12, O = 16, H = 1

CO ☐

CO₂ ☐

CH₄ ☐

C₂H₆ ☐

- 2.3** Calculate the percentage by mass of nitrogen in ammonium carbonate, (NH₄)₂CO₃.
Give your answer to the nearest percent.

.....%

3.1 A 250 cm³ sample of sugar solution contains 3.28 g of glucose.

a) Calculate the volume of the solution in dm³.

..... dm³

b) Calculate the concentration of the solution in g/dm³.

..... g/dm³

3.2 An 800 cm³ sample of potassium nitrate solution contains 14.2 g of potassium nitrate.
Calculate the concentration of the solution in g/dm³.

..... g/dm³

3.3 A solution of potash alum is made by dissolving 35.7 g of potash alum
in a known volume of water.
The resulting solution has a concentration of 238 g/dm³.
Calculate the volume the solution created.

..... dm³

3.4

A solution of calcium chloride has a concentration of 75 g/dm^3 .
Calculate the mass of calcium chloride needed to make 800 cm^3 of the solution.

..... g

3.5

0.052 mol of hydrogen chloride is dissolved in 0.40 dm^3 of water.
Calculate the concentration of the hydrochloric acid solution that forms.

..... mol/dm^3

3.6

A student makes a 500 cm^3 sample of nitric acid by
dissolving 0.63 mol of hydrogen nitrate in water.
Calculate the concentration of the acid in mol/dm^3 .

..... mol/dm^3

3.7

500 cm³ of potassium nitrate (KNO₃) solution contains 6.06 g of potassium nitrate.

Calculate the concentration of the solution in mol/dm³.

Relative formula mass: KNO₃ = 101

..... mol/dm³

3.8

Lithium hydroxide (LiOH) is an alkali.

Calculate the mass of lithium hydroxide needed to make 400 cm³ of a solution with a concentration of 0.0750 mol/dm³.

Relative atomic masses: Li = 7, O = 16, H = 1

..... g

Calculations with moles

R223

4.1

Calculate the number of magnesium atoms in each of the samples below.

Give your answers in standard form.

The Avogadro constant is 6.02×10^{23} per mole.

a) 1 mole of magnesium

.....

b) 2 moles of magnesium

.....

c) 10 moles of magnesium

.....

4.2

The Avogadro constant is 6.02×10^{23} per mole.

Calculate the number of moles of carbon atoms represented by the following numbers of atoms.

Give your answers to 3 significant figures.

a) 2.81×10^{23} atoms

.....mol

b) 9.70×10^{25} atoms

.....mol

4.3

Calculate the number of moles in 60 g of calcium carbonate, CaCO_3 .

.....mol

4.4

A scientist has a 368 g sample of sulfur.

How many sulfur atoms are in the sample? Give your answer in standard form.

The Avogadro constant is 6.02×10^{23} per mole.

Relative atomic mass: S = 32

.....

- 4.5** Calculate the number of moles in 58 g of ethanol, $\text{C}_2\text{H}_5\text{OH}$.
Give your answer to 2 significant figures.
Relative atomic masses: $\text{H} = 1$, $\text{C} = 12$, $\text{O} = 16$

.....

- 4.6** Dodecahedral fullerene is a molecule with the formula C_{20} .
Calculate the number of dodecahedral fullerene molecules that can
be made from 1 mole of carbon atoms.
The Avogadro constant is 6.02×10^{23} per mole.

.....

- 4.7** Calculate the total number of atoms in 688.8 g of calcium nitrate $\text{Ca}(\text{NO}_3)_2$.
The Avogadro constant is 6.02×10^{23} per mole.
Relative atomic masses: $\text{Ca} = 40$, $\text{N} = 14$, $\text{O} = 16$

.....

5.1 The symbol equation below shows the thermal decomposition of calcium carbonate.

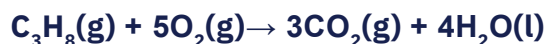


Calculate the mass of calcium oxide made if 50 g of calcium carbonate decomposes completely.

Relative formula masses: $\text{CaCO}_3 = 100$, $\text{CaO} = 56$, $\text{CO}_2 = 44$

.....g

5.2 The symbol equation below shows the combustion of propane.



Calculate the mass of water made if 22 g of propane completely combusts.

Relative formula masses: $\text{C}_3\text{H}_8 = 44$, $\text{O}_2 = 32$, $\text{CO}_2 = 44$, $\text{H}_2\text{O} = 18$

.....g

5.3 The symbol equation below shows the decomposition of magnesium carbonate.



Calculate the mass of magnesium carbonate needed to produce 11 g of carbon dioxide.

Relative atomic masses: $\text{C} = 12$, $\text{O} = 16$, $\text{Mg} = 24$

.....g

- 5.4** The symbol equation below shows the oxidation of sulfur dioxide (SO₂) into sulfur trioxide (SO₃).



Calculate the mass of sulfur dioxide needed to produce 40 kg of sulfur trioxide.

.....kg

Balancing equations using molar calculations

R143

- 6.1** A sample of lithium sulfide was made by reacting 0.30 moles of lithium metal with 0.15 moles of sulfur.

The lithium sulfide was the only product.

The formula of the lithium sulfide made was Li_xS_y.

Use the information above to determine the lowest whole numbers that represent x and y .

$x =$ $y =$

- 6.2** 5.4 g of aluminium (Al) reacts with 21.3 g of chlorine (Cl₂) to produce aluminium chloride (AlCl₃). This can be represented by the equation:



What are the smallest values of x , y and z which balance this equation?

Relative atomic mass: Al = 27

Relative formula masses: Cl₂ = 71, AlCl₃ = 133.5

$x =$ $y =$ $z =$

6.3

26.4 g of carbon dioxide reacts with 10.8 g of water.

18.0 g of glucose ($\text{C}_6\text{H}_{12}\text{O}_6$) and 19.2 g of oxygen gas are produced.

Calculate the simplest whole number ratio of:

moles of carbon dioxide : moles of water: moles of glucose : moles of oxygen

Relative formula masses: $\text{CO}_2 = 44$, $\text{H}_2\text{O} = 18$, $\text{C}_6\text{H}_{12}\text{O}_6 = 180$, $\text{O}_2 = 32$

..... : : :

6.4

Aluminium reacts with fluorine to make aluminium fluoride.

108 g of aluminium reacted with 228 g of fluorine molecules to make 336 g of aluminium fluoride.

a) Use the information above to work out the simplest whole number ratio of:

moles of aluminium atoms : moles of fluorine atoms

Relative atomic masses: $\text{Al} = 27$, $\text{F} = 19$

..... :

b) Write a balanced equation for this reaction.

.....

1.1 Match the formula of each ion to its correct name.

Formula	Name
F^-	bromide
S^{2-}	chloride
Br^-	sulfide
Cl^-	oxide
O^{2-}	fluoride

1.2 Tick one box in each row of the table to show whether the name of each substance ends in -ide, -ate or -ine.

Substance	Name ending		
	-ide	-ate	-ine
$NaClO_3$			
$NaCl$			
Cl_2			
Cl^-			

1.3 Write the correct name of each of the following ions.

a) OH^-

.....

b) SO_4^{2-}

.....

c) NO_3^-

.....

1.4 Name the following ionic compounds.

a) KF

.....

b) CuS

.....

c) ZnSO_4

.....

d) LiNO_3

.....

Ions

R199

2.1 Sulfur forms S^{2-} ions.

Use the Periodic Table to work out how many electrons there are in a S^{2-} ion.

.....

2.2 Magnesium forms stable ions with a +2 charge.

Describe how the electron configuration of magnesium changes when it forms ions.

.....

.....

2.3 Titanium forms Ti^{4+} ions.

Use the Periodic Table to work out how many electrons there are in a Ti^{4+} ion.

.....

2.4

Using the Periodic Table, work out how many protons, neutrons and electrons are in a stable beryllium ion.

number of protons:

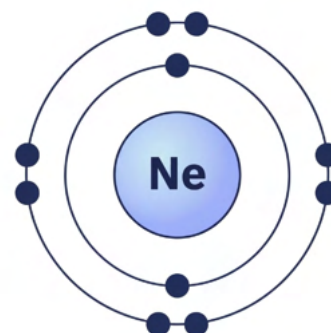
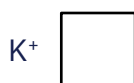
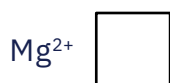
number of electrons:

number of neutrons:

2.5

The diagram shows the electron configuration of a neon atom. Which of these ions have the same electron configuration as a neon atom?

Tick **all** that apply.



2.6

An ion of element M can be represented as $^{137}\text{M}^{2+}$.

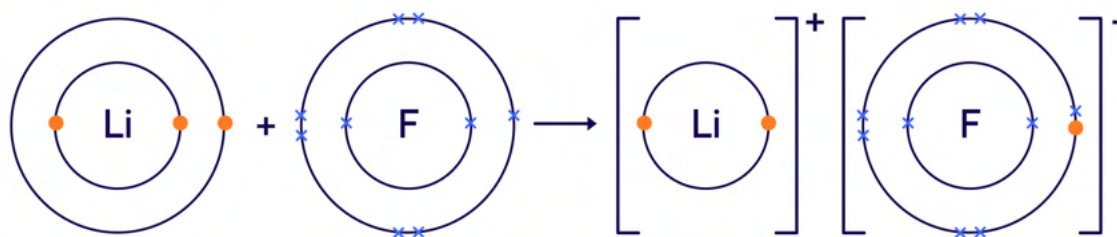
It contains 54 electrons.

Calculate the number of protons and the number of neutrons in this ion.

number of protons:

number of neutrons:

3.1 This dot and cross diagram shows the formation of lithium fluoride (LiF).



Describe the movement of electrons when lithium and fluorine form lithium fluoride.

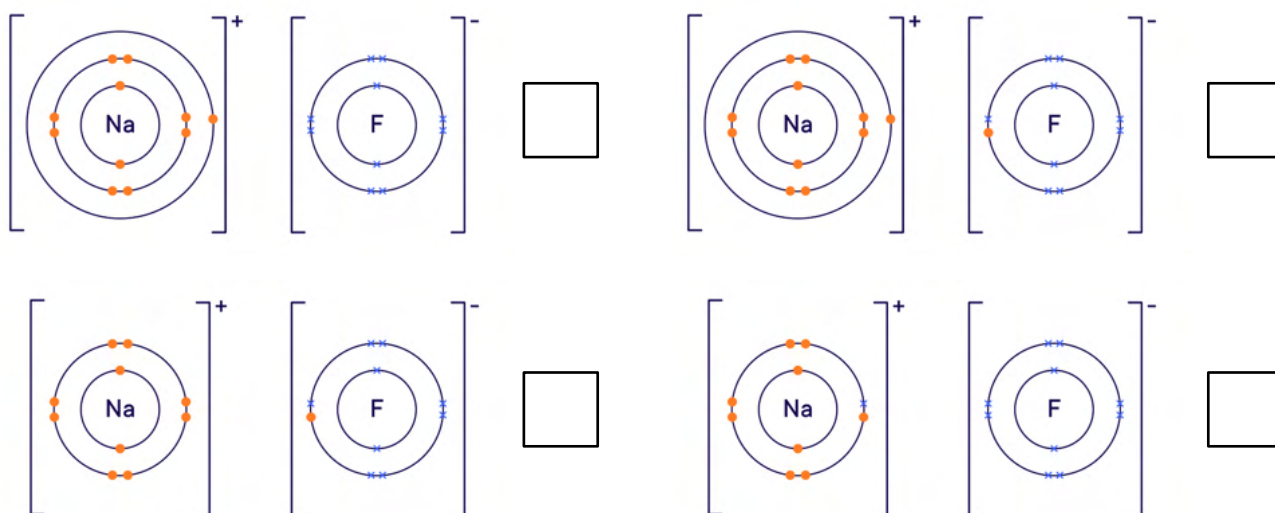
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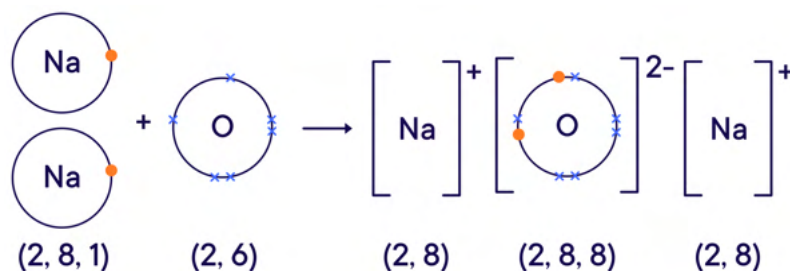
.....

3.2 Which is the correct dot and cross diagram for sodium fluoride?



3.3

The dot and cross diagram shows the formation of sodium oxide (Na_2O) from its elements. Only the outer shells are shown.



a) Describe the movement of electrons when sodium and oxygen form sodium oxide.

.....

.....

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.....

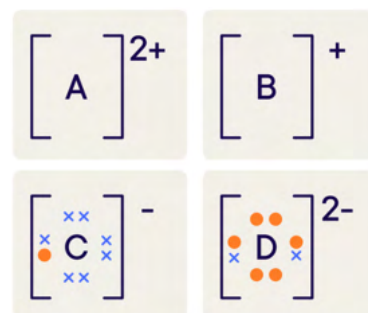
b) How many sodium ions are needed to cancel the charge on one oxide ion?

.....

3.4

Here are four dot and cross diagrams. The atomic symbols of the elements have been replaced with the letters A -D.

Tick one box in each row of the table to show which ion each statement describes.



Statement	Ion			
	A	B	C	D
An ion for a Group 7 element				
An ion formed when an atom loses two electrons				
Could be a sulfide ion				

- 4.1** Tick one box in each row of the table to show if each of these pairs of atoms are likely held together by covalent bonding or not.

	Type of bonding	
	Covalent	Not covalent
Metal atom to metal atom		
Metal atom to non-metal atom		
Non-metal atom to non-metal atom		

- 4.2** Describe a covalent bond in terms of electrons.

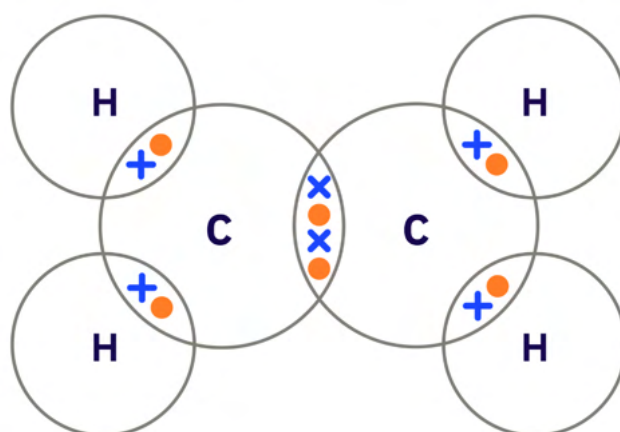
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- 4.3** Here is a diagram to show the covalent bonding in a molecule of ethene.
How many single and double covalent bonds are shown?



number of single covalent bonds:

number of double covalent bonds:

- 4.4** Some different substances are given below.
Match each one to the correct description.

Substance	Description
Covalent element	A single neon atom
Non-covalent element	Two oxygen atoms bonded together
Non-covalent compound	One hydrogen and one iodine atom bonded together
Covalent compound	One sodium ion and one chloride ion bonded together

- 4.5** The main chemical in vinegar is ethanoic acid.
Ethanoic acid contains six single covalent bonds and one double covalent bond.
How many bonding electrons are there in a molecule of ethanoic acid?

.....

- 4.6** Look at the diagram of a molecule of ethanoic acid.

a) What is the molecular formula of ethanoic acid?

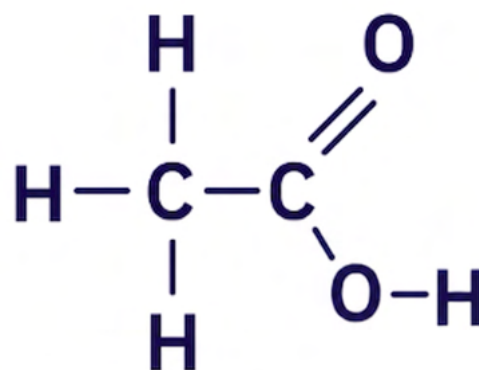
.....

b) How many single covalent bonds are shown?

.....

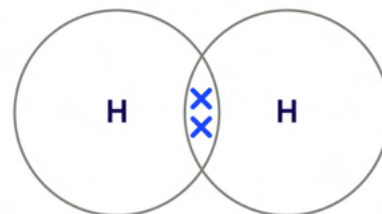
c) How many double covalent bonds are shown?

.....



4.7

A student has drawn a dot and cross diagram to show hydrogen.
Describe the mistake the student has made.

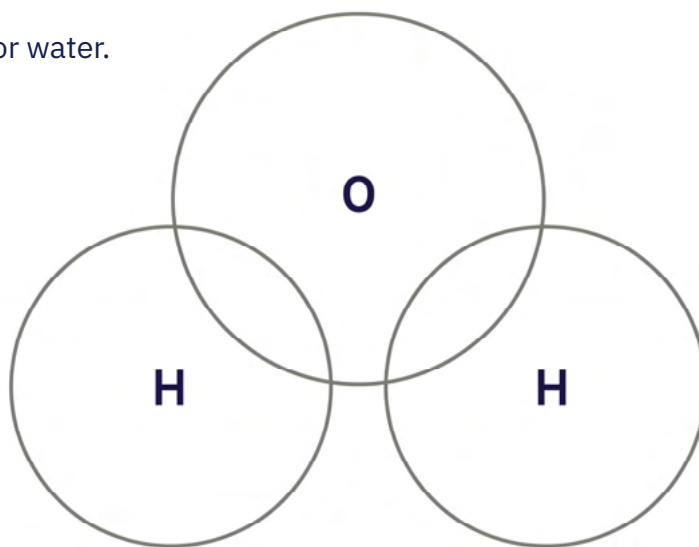


.....

.....

4.8

Complete the dot and cross diagram for water.
Show outer shell electrons only.



Large covalent structures

R916, R901

5.1

These diagrams represent the structures of some large covalent molecules.

Which structure could represent

a) diamond?

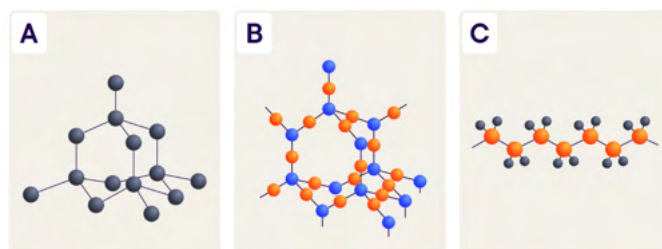
A ☐ B ☐ C ☐

b) polyethene?

A ☐ B ☐ C ☐

c) silicon dioxide?

A ☐ B ☐ C ☐



5. Bonding and Properties of Materials

- 5.2** Complete these sentences to describe the structure of diamond.
Choose the correct word from each box.

Diamond is made from

carbon
nitrogen
silicon
oxygen

 atoms.

All the atoms are joined together in a

simple
giant
polymer

 structure.

The atoms are joined together by

covalent
ionic
metallic

 bonds.

- 5.3** Tick boxes in each row of the table to show whether each feature applies to simple molecular substances or giant covalent substances.
You may tick more than one box per row.

Feature	Type of substance	
	Simple molecular	Giant covalent
Atoms are held together with covalent bonds		
Contains only a few atoms		
Examples include diamond and silicon dioxide		

- 5.4** Tick boxes in each row of the table to show whether each statement describes a property of diamond or graphite.
You may tick more than one box per row.

Property	Diamond	Graphite
Hard		
Soft and slippery		
Electrical conductor		
High melting point		

5.5 Diamond is a giant covalent structure in which each carbon atom is bonded to four other carbon atoms.
With reference to the electronic configuration of carbon, explain why it forms bonds with four other carbon atoms.

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5.6 Match each property of graphite to the structural feature that gives it this property.

Feature	Property
Strong covalent bonds within layers	Good electrical conductor
Delocalised electrons	Soft and slippery
No covalent bonds between layers	High melting point

5.7 Diamond is often used to make drill bits because it is very hard.
Explain why diamond is hard.

.....

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5.8

Graphite is a form of carbon.

It is soft and slippery and is an electrical conductor.

Explain why graphite is soft and an electrical conductor.

Refer to the structure and bonding of graphite in your answer.

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Metallic bonding

R928

6.1

Describe metallic bonding.

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.....

.....

6.2

Mercury is a metal.

It is shiny, a good electrical conductor, and has a melting point of -39°C .

Suggest **one** property of mercury that is unusual for a metal.

.....

.....

- 6.3** The alkali metals are found in Group 1 of the Periodic Table.
The table shows their melting points as you go down the group.

Alkali metal	Melting point (°C)
Lithium	181
Sodium	98
Potassium	63
Rubidium	39
Caesium	29

- a) Describe the trend seen in the melting points of the Group 1 metals.

.....

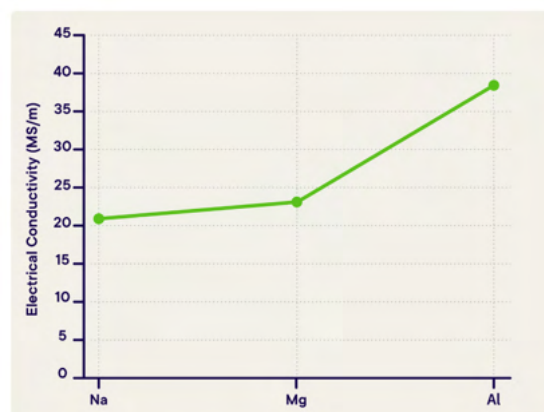
.....

- b) Suggest how the strength of the metallic bond changes as you go down Group 1.

.....

.....

- 6.4** The graph shows the relative electrical conductivity of the first three metals in period 3 of the Periodic Table. Suggest why the metals show an increase in conductivity as they move across the period.



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7.1 An unknown substance is made from a metal and a non-metal.

- It has a melting point of 2278°C.
- It is soluble in water.
- It does not conduct electricity as a solid.

What type of substance is this?

Giant covalent ☐ Simple covalent ☐ Ionic ☐ Metallic ☐

7.2

Substance	Melting point (°C)	Conducts electricity when solid?	Conducts electricity when molten?
A	1180	No	Yes
B	1540	Yes	Yes
C	120	No	No
D	1720	No	No

Which of the substances in the table is most likely to be an ionic compound?

A ☐ B ☐ C ☐ D ☐

7.3

The table shows the melting points of the Group 2 chlorides.

- a) Describe the pattern in the melting points of the Group 2 chlorides.

.....

.....

.....

Name of chloride	Melting point (°C)
Beryllium chloride	399
Magnesium chloride	714
Calcium chloride	772
Strontium chloride	874
Barium chloride	960

- b) Which of the Group 2 chlorides needs the most energy to overcome the bonds between the ions?

.....

7.4

Magnesium carbonate contains Mg^{2+} and CO_3^{2-} ions.

Explain why solid magnesium carbonate cannot conduct electricity but solid magnesium can.

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7.5

An unknown substance is made from a non-metal element.

- It has a melting point of -78°C .
- It does not conduct electricity.

What type of substance is this?

Giant covalent ☐ Simple covalent ☐ Ionic ☐ Metallic ☐

7.6

The diagram shows some water molecules.

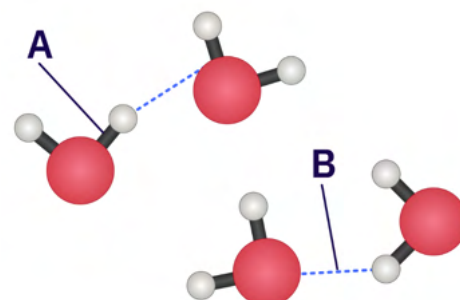
State the type of bonds or forces represented by each label.

a) Label A.

.....

b) Label B.

.....



5. Bonding and Properties of Materials

- 7.7** Simple covalent compounds:
- have low melting points
 - do not conduct electricity.
- Match each of these properties to the explanation of the property.

Property	Explanation
Low melting point	Ions are free to move
Do not conduct electricity	No charged particles free to move
	Weak intermolecular forces
	Strong covalent bonds

- 7.8** Methane is a simple molecular, covalent compound.
It has a low boiling point of -161.5°C .
Explain why methane has a low boiling point.

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- 7.9** An unknown substance is made from non-metal elements.
- It has a melting point of 1525°C .
 - It is insoluble in water.
 - It does not conduct electricity.

What type of structure is this substance likely to have?

Giant covalent

☐

Simple covalent

☐

Ionic

☐

Metallic

☐

7.10

The graph shows the boiling points of the Group 4 hydrides. These are Group 4 elements that have reacted with hydrogen.



a) Describe what happens to the boiling point of the hydride as you go down Group 4.

.....

.....

b) Which of the following factors is most likely to cause this trend?

The number of bonds

☐

The number of electron

☐

The reactivity of the elements increases

☐

The size of the molecules increases

☐

7.11

Four large covalent structures are shown. Match each one to its name.

Structure

A

B

C

D

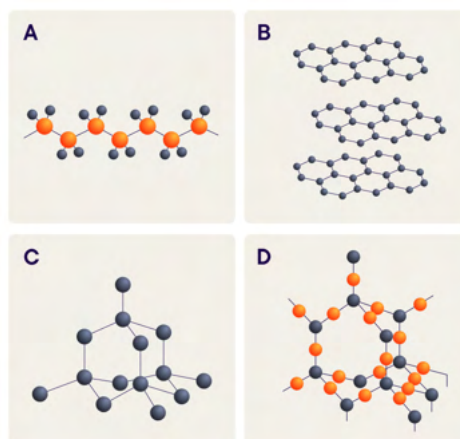
Name

Graphite

Diamond

Polythene

Silicon dioxide



7.12 Look at the data in the table.

Substance	Melting point (°C)	Electrical conductivity
A	1710	Very low
B	110	Very low
C	-39	Very high

a) Which substance is most likely to be a giant covalent structure?

A ☐

B ☐

C ☐

b) Which substance is most likely to be a polymer?

A ☐

B ☐

C ☐

7.13 Boron nitride has a giant covalent structure.
It has a melting point around 3000°C.
Explain why boron nitride has a high melting point.

.....

.....

.....

.....

7.14 The table shows the boiling points of two Group 4 oxides, carbon dioxide and silicon dioxide.
Explain why silicon dioxide has a high boiling point compared to carbon dioxide.

Compound	Boiling point (°C)
Carbon dioxide	-78
Silicon dioxide	2950

.....

.....

.....

.....

7.15

Element	Melting point (°C)	Electrical conductivity
A	3547	Low
B	115	Low
C	1085	High
D	-101	Low

Which of the elements in the table is likely to be a metal?

A ☐B ☐C ☐D ☐

7.16

An unknown substance:

- has a melting point of 649°C.
- is insoluble in water.
- conducts electricity when solid and liquid.

What type of substance is this?

Giant covalent

☐

Simple covalent

☐

Ionic

☐

Metallic

☐

1.1 Match each type of reaction to the correct definition.

Reaction	Definition
Endothermic	A reaction that does not involve energy
Exothermic	A reaction that transfers equal amounts of energy to and from the surroundings
	A reaction that transfers energy to the surroundings
	A reaction that takes in energy from the surroundings

1.2 A student mixes sodium hydroxide solution with hydrochloric acid.

a) What type of reaction is this?

Neutralisation ☐

Displacement ☐

Precipitation ☐

Thermal decomposition ☐

b) The student finds that the temperature of the solution increases as the reaction progresses. Give the name for the type of reaction that causes a temperature increase.

.....

6. Energetics and kinetics

1.3

A student was investigating the energy changes when different salts were dissolved in water. The results are shown.

	Salt A	Salt B	Salt C	Salt D
Temperature at start (°C)	18.0	18.0	18.0	18.0
Temperature at end (°C)	22.1	16.5	24.2	15.8
Temperature change (°C)	4.1	-1.5		

a) Calculate the temperature change for salts C and D.

temperature change for salt C:°C

temperature change for salt D:°C

b) Which salt produces the largest endothermic temperature change when it dissolves?

A ☐

B ☐

C ☐

D ☐

1.4

The following processes and reactions cause an increase or decrease in temperature. Match each process or reaction with the correct description.

Process or reaction

Displacement

Dissolving

Neutralisation

Precipitation

Description

A reaction between an acid and a base.

A more reactive metal takes the place of a less reactive metal.

Two solutions react to produce an insoluble solid.

A soluble salt mixes completely with a liquid.

1.5

The equation shows the reaction between sodium hydroxide and hydrochloric acid.



A student performed this reaction and determined that 55 kJ of energy was released into the surroundings.

Which of the following is true of the reaction?

The products contain 55 kJ more energy than the reactants. ☐

The products contain 55 kJ less energy than the reactants. ☐

The products contain the same energy as the reactants. ☐

It is not possible to compare the energy of the products and reactants. ☐

1.6

A student investigated the temperature change during a reaction between citric acid and sodium hydrogen carbonate solution.

Mass of citric acid added (g)	Temperature of solution (°C)
0.0	23.3
0.2	23.0
0.4	22.7
0.6	22.4
0.8	23.4
1.0	21.8

This is the method they used:

Step 1: Measure 25 cm³ of sodium hydrogen carbonate solution into a polystyrene cup.

Step 2: Add 0.2 g of citric acid and stir.

Step 3: Measure the temperature of the solution.

Step 4: Repeat steps 2 and 3 until a total of 1.0 g of citric acid has been added.

a) There is one anomalous reading for the temperature.

What was the mass of citric acid added that gave an anomalous result?

.....g

b) Explain whether the reaction is endothermic or exothermic.

.....

.....

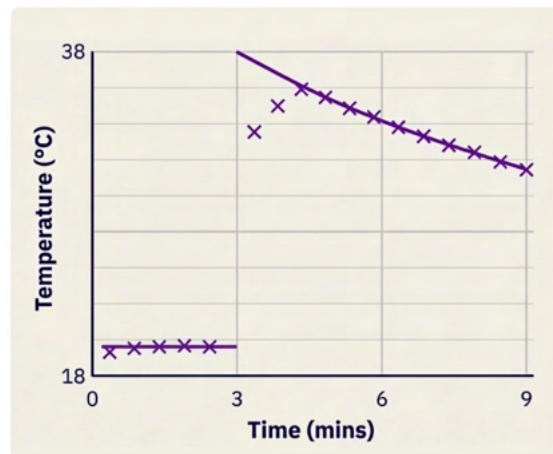
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.....

6. Energetics and kinetics

1.7

A student was investigating the temperature changes when magnesium powder reacts with copper sulfate solution. They took the temperature of the copper sulfate solution every 30 seconds except at 3 minutes. They plotted a graph of their results as shown.



a) Suggest what the student did at minute 3 instead of recording the temperature.

.....

.....

b) Explain whether the reaction between magnesium and copper sulfate solution is endothermic or exothermic.

.....

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.....

Reaction profiles

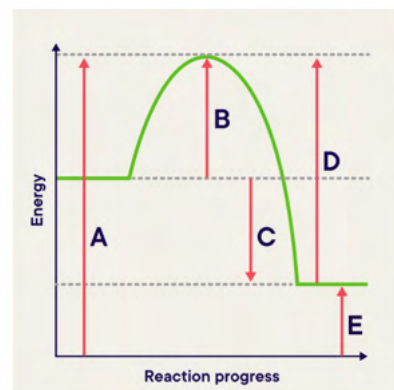
R675

2.1

Look at the reaction profile.
Give the label that corresponds to the following quantities.

The activation energy:

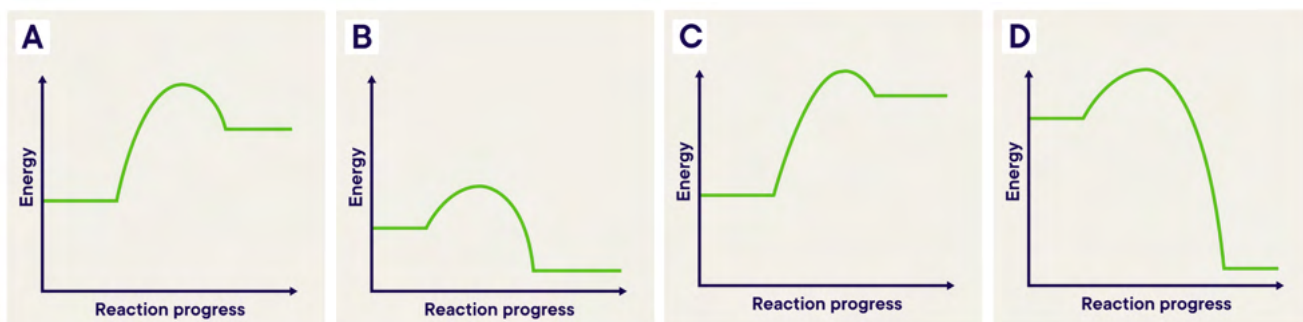
The overall energy change of the reaction:



6. Energetics and kinetics

2.2

Look at the reaction profiles.



Tick one box in each row of the table to show whether each profile shows an endothermic or an exothermic reaction.

Reaction profile	Endothermic	Exothermic
A		
B		
C		
D		

2.3

In Chemistry, what is meant by the term activation energy?

.....

.....

2.4

Here is the reaction profile for this neutralisation reaction:



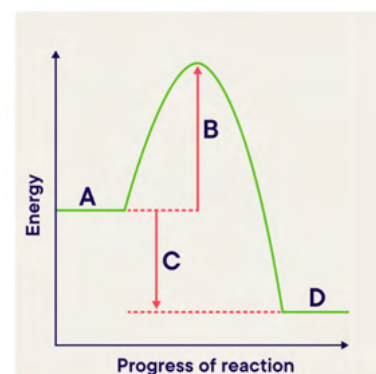
Which label shows the energy of hydrochloric acid and sodium hydroxide?

A ☐

B ☐

C ☐

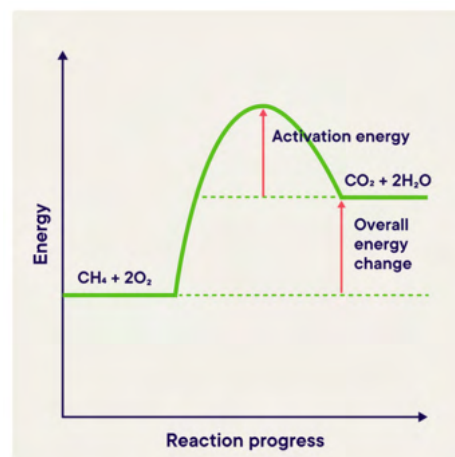
D ☐



6. Energetics and kinetics

2.5

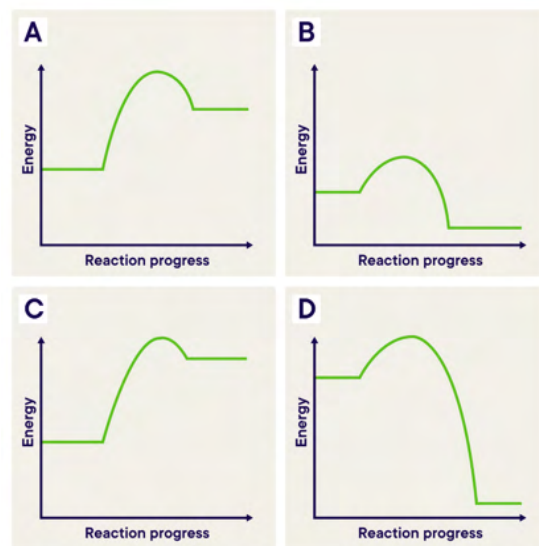
Methane and oxygen react to form carbon dioxide and water.
This reaction releases energy.
A student drew this reaction profile for the reaction.
Describe the **two** errors that the student has made.



2.6

A scientist measures the difference in the energy of the reactants and products of four reactions.
She uses these to help draw the reaction profile of the four reactions.

Reaction	Change in energy (kJ/mol)
?	-75
?	+68
?	+46
?	-10



Match each value in the table to the reaction profile that could correspond to each reaction.

Change in energy

-75 kJ/mol

+68 kJ/mol

+46 kJ/mol

-10 kJ/mol

Reaction profile

A

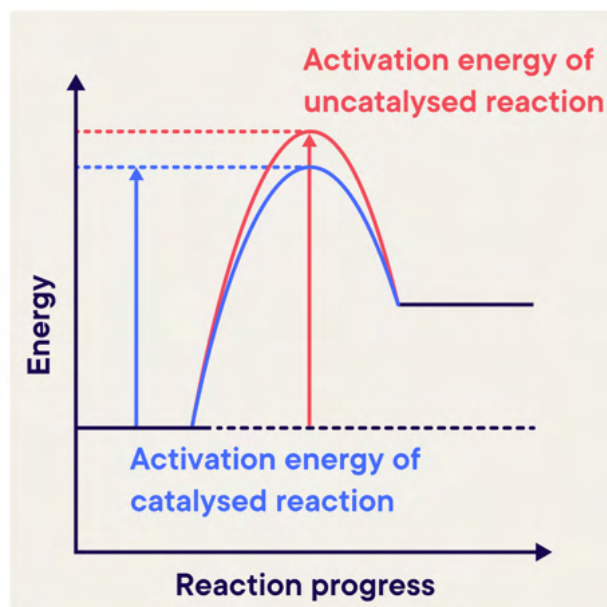
B

C

D

2.7

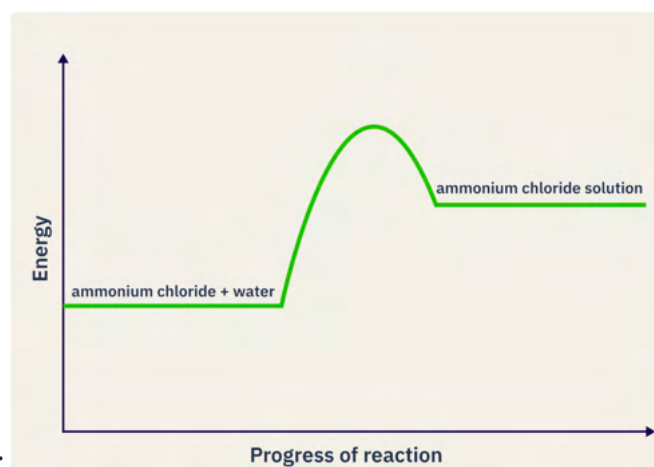
The image shows the reaction profile for a catalysed and an uncatalysed reaction. Use this image and your understanding of activation energy to suggest how a catalyst increases the rate of a chemical reaction.



2.8

When ammonium chloride dissolves in water, it is an endothermic process. The diagram shows the reaction profile for this process.

Explain how the diagram shows that dissolving ammonium chloride in water is an endothermic process.



3.1

The table shows the total energy change for four different chemical reactions.
Write them in order of increasing exothermicity.

Reaction	Energy required to break bonds (kJ/mol)	Energy released when bonds form (kJ/mol)
A	2000	3000
B	1500	1000
C	3600	3000
D	2200	2300

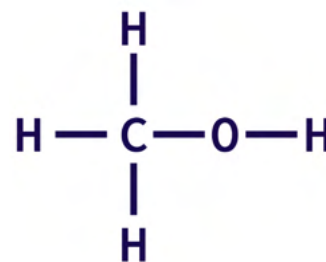
Least exothermic $\longrightarrow$ Most exothermic

.....,,,

3.2

The image shows a molecule of methanol.

Bond	C-C	C-H	C-O	O-H
Bond energy in kJ/mol	348	412	358	463



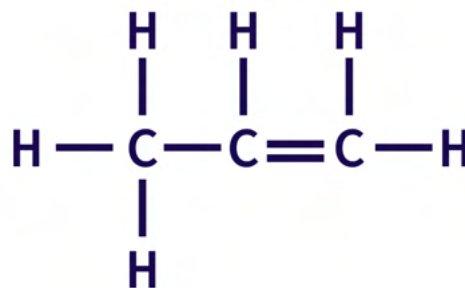
Calculate the total energy required to break all the bonds in one mole of methanol molecules.

.....kJ

3.3

The image shows a molecule of propene.

Bond	C-C	C-H	C=C
Bond energy in kJ/mol	348	412	612



Calculate the total energy released when all the bonds in one mole of propene molecules are formed.

.....kJ

3.4

The displayed formula equation for the reaction between hydrogen and chlorine is shown.



The table shows the bond energies of the bonds in the reaction.

Bond	H-H	Cl-Cl	H-Cl
Bond energy in kJ/mol	436	242	431

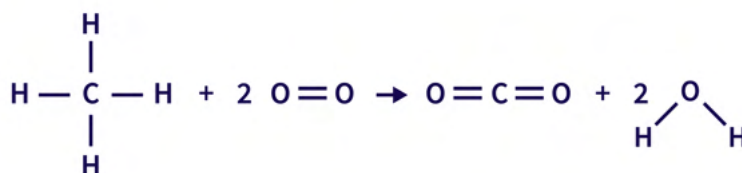
Calculate the overall energy change for this reaction.

.....kJ/mol

3.5

The displayed formula equation for the combustion of methane is shown.

The table shows the bond energies of the bonds in the reaction.



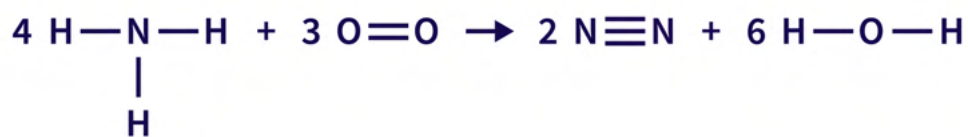
Bond	C-C	C-H	O=O	C=O	O-H
Bond energy in kJ/mol	348	412	498	799	463

Calculate the overall energy change for this reaction.

.....kJ/mol

3.6

The displayed formula equation for the reaction between ammonia and oxygen is shown.



The overall energy change of this exothermic reaction is -1224 kJ.

The table shows the bond energies of the bonds in the reaction.

Bond	N-H	O=O	N≡N	O-H
Bond energy in kJ/mol	391	498	945	?

Calculate the bond energy of the O-H bond.

.....kJ/mol

Calculating reaction rates

R771

4.1

A student investigated the reaction between magnesium and hydrochloric acid.

Calculate the mean rate of reaction during the first 40 seconds.

Time (s)	Volume of gas produced (cm ³)
0	0
10	18
20	32
30	44
40	52
50	58

.....cm³/s

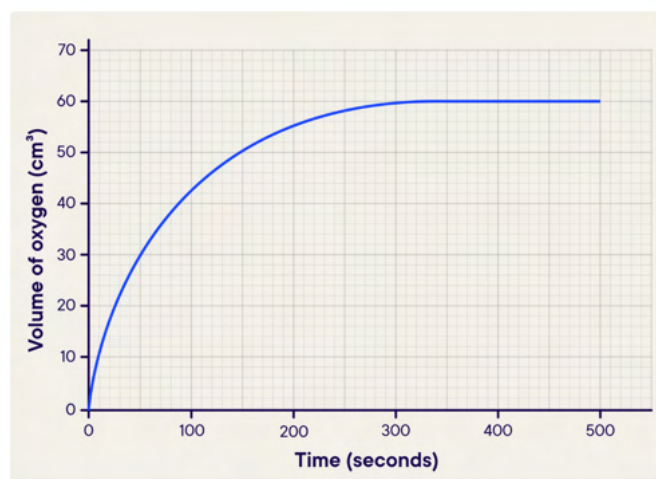
6. Energetics and kinetics

- 4.2** In a reaction, 24 cm^3 of gas was produced in 3 minutes and 20 seconds. Calculate the mean rate of reaction in cm^3/s .

..... cm^3/s

- 4.3** The graph shows the volume of oxygen produced over time for the decomposition of hydrogen peroxide.

Calculate the mean rate of reaction for the first 50 seconds.

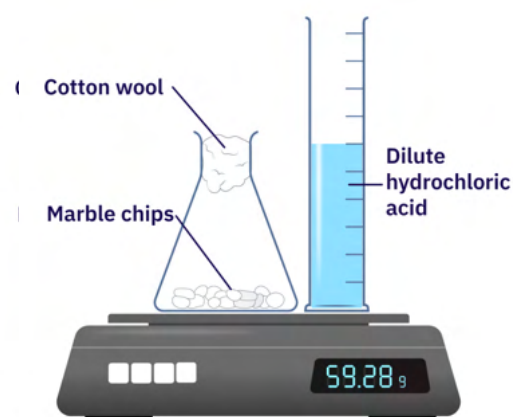


..... cm^3/s

- 4.4** The apparatus shown was used to investigate the rate of reaction between hydrochloric acid and calcium carbonate.

The table shows the change in mass over a period of 5 minutes.

Total mass at start (g)	Total mass after 5 min (g)
59.28	58.89



Calculate the mean rate of reaction in g/s .

..... g/s

4.5

A student investigated the reaction between zinc and sulfuric acid.

They recorded the volume of gas produced by the reaction in 60 seconds.

They repeated their investigation five times.

Test	Volume of gas produced (cm ³)
1	54
2	52
3	18
4	50
5	49

a) Which test gave an anomalous result?

Test 1 ☐

Test 2 ☐

Test 3 ☐

Test 4 ☐

Test 5 ☐

b) Ignoring the anomalous result, calculate the mean rate of reaction.

Give your answer to 2 significant figures.

.....cm³/s

4.6

A student was investigating the reaction between marble chips and hydrochloric acid.

They repeated their experiment four times. Each time, they calculated the mean rate of reaction.

Calculate the mean time to collect 50 cm³ of gas to the nearest second.

Do not include any anomalous results in your calculation.

Test	Rate of reaction (cm ³ /s)
1	0.83
2	0.79
3	0.64
4	0.84

.....s

6. Energetics and kinetics

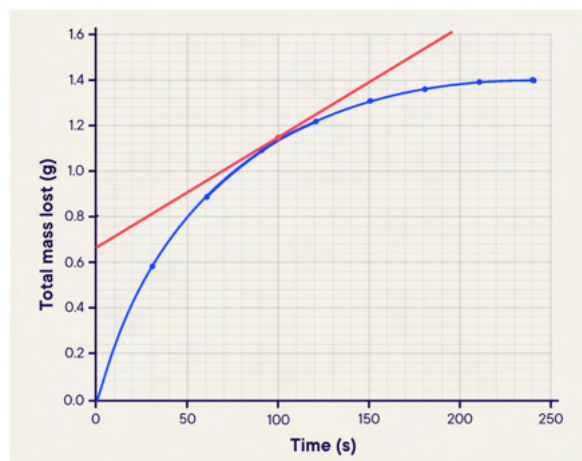
4.7

A student investigated the reaction between magnesium oxide and hydrogen peroxide solution. They monitored the reaction by measuring the mass lost from the reaction flask.

The graph shows their results.

A tangent is drawn to the graph at 100 seconds.

Use the tangent to estimate the rate of reaction at 100 seconds.



.....g/s

Collision theory

R895

5.1

Sodium thiosulfate solution and hydrochloric acid react to produce a cloudy precipitate. Increasing the concentration of sodium thiosulfate increases the rate of reaction.

Which **two** statements explain why the rate increases when the concentration of sodium thiosulfate increases?

There are more frequent collisions ☐

The particles are closer together ☐

The particles are larger ☐

More particles have at least the activation energy ☐

The particles are moving slower ☐

5.2

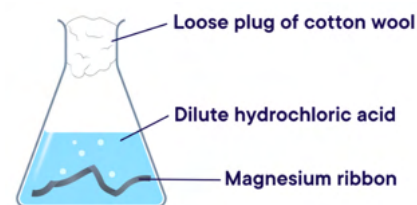
A student used this equipment to investigate the reaction between magnesium and hydrochloric acid.

They measured the mass lost from the flask during the reaction.

They carried out the experiment twice:

- For the first experiment, the hydrochloric acid was at room temperature.
- For the second experiment, they warmed the acid slightly.

State the effect of the higher temperature of the acid on the rate of mass loss from the flask.



.....

.....

5.3

Marble chips (calcium carbonate) and hydrochloric acid react in the reaction shown below.



Which of the following would **decrease** the rate of reaction?

Using smaller
marble chips ☐

Using more dilute
hydrochloric acid ☐

Using a larger volume of
hydrochloric acid ☐

Using a larger mass of
marble chips ☐

5.4

A scientist is reacting hydrogen and oxygen gas to produce water.

They increase the pressure inside the reaction chamber.

This increases the rate of reaction.

Which **two** statements explain why the rate increases when the pressure in the reaction chamber increases?

There are more
frequent collisions ☐

The particles are
closer together ☐

The particles
increase in size ☐

More particles have at least
the activation energy ☐

The particles are
moving slower ☐

5.5

A student determined the rate of reaction at regular time intervals during a reaction between magnesium metal and hydrochloric acid.

They noticed the rate decreased as the reaction progressed.

Explain why the rate of reaction decreased as the reaction progressed.

You should give your answer in terms of particles.

.....

.....

.....

.....

5.6

A student is investigating the rate of the reaction between a metal and hydrochloric acid. Explain why the rate of this reaction would increase if the concentration of the acid is increased.

5.7

Powdered calcium carbonate reacts faster with hydrochloric acid than an equivalent mass of calcium carbonate lumps. Explain, in terms of particles, why powdered calcium carbonate results in an increased rate of reaction.

Catalysts

R601

6.1

Describe what a catalyst is.

6.2

Amir says a catalyst will decrease in mass because it is used up in a reaction.

a) Do you agree with Amir?

I do agree with Amir

☐

I do **not** agree with Amir

☐

b) Give a reason for your answer.

.....

.....

6.3

Platinum is used as a catalyst in cars.

It speeds up the conversion of carbon monoxide and nitrogen monoxide into carbon dioxide and nitrogen.

Which equation shows this reaction?

carbon monoxide + nitrogen monoxide + platinum → nitrogen + carbon dioxide

☐

carbon monoxide + nitrogen monoxide $\xrightarrow{\text{platinum}}$ nitrogen + carbon dioxide

☐

carbon monoxide + nitrogen monoxide → nitrogen + carbon dioxide

☐

carbon monoxide + nitrogen monoxide → nitrogen + carbon dioxide + platinum

☐

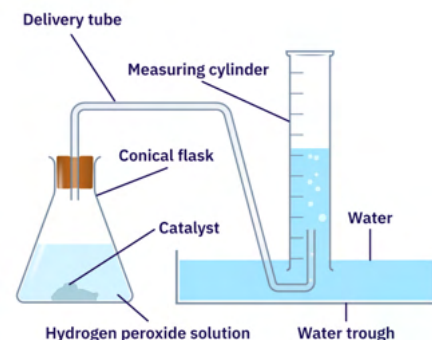
6. Energetics and kinetics

6.4

You can measure how quickly hydrogen peroxide decomposes by measuring how much gas is released over time.

A student carries out this experiment with three different catalysts.

Their results are shown in the table.



Catalyst	Volume of oxygen after 20 s (cm ³)	Volume of oxygen after 40 s (cm ³)	Volume of oxygen after 60 s (cm ³)
Manganese dioxide	82	100	100
Iron	45	60	62
Copper oxide	20	26	32

a) Which catalyst was the most effective?

Manganese dioxide

☐

Iron

☐

Copper oxide

☐

b) Give a reason for your answer.

.....

.....

6.5

A chemical reaction in a factory is catalysed by platinum.

This is a very expensive material.

Explain what the ongoing cost of the catalyst will be to the factory.

.....

.....

.....

.....

7.1 Here is an example of a reversible reaction: $\text{NH}_4\text{Cl} \rightleftharpoons \text{NH}_3 + \text{HCl}$
The reaction reaches equilibrium.

a) Which reactions occur at dynamic equilibrium?

Just the forward reaction ☐

Just the reverse reaction ☐

Both the forward and reverse reactions ☐

No reactions occur ☐

b) How will the amounts of reactants and products change at equilibrium?

The amount of products will increase ☐

The amount of reactants will increase ☐

The amounts of both reactants and products will increase ☐

The amounts of both reactants and products will stay constant ☐

7.2 Hydrogen gas and chlorine gas can react to produce hydrogen chloride.
hydrogen + chlorine $\rightleftharpoons$ hydrogen chloride
In a sealed container, the reaction can reach equilibrium.
Which **two** statements are true when the reaction is at equilibrium?

The amounts of each substance remain constant. ☐

The forward and reverse reactions become exothermic. ☐

The reaction between hydrogen and chlorine stops. ☐

The rates of the forward and reverse reactions are equal. ☐

The container is no longer sealed. ☐

7.3 The reaction between ammonia and hydrochloric acid is reversible.
 $\text{NH}_4\text{Cl} \rightleftharpoons \text{NH}_3 + \text{HCl}$
The energy change of the forward reaction is +93 kJ/mol.
What is the energy change of the reverse reaction?

.....kJ/mol

7.4

Nitrogen dioxide reacts to form dinitrogen tetroxide.

The equation for the reaction is:



Describe how a reaction, such as this, reaches equilibrium.

.....

.....

.....

.....

7.5

This reaction occurs in a sealed container.



Eventually, the reaction reaches equilibrium.

Tick one box in each row of the table to show what will happen to the masses of each substance in the equation at equilibrium.

	Change in mass at equilibrium		
	Increases	Decreases	Stays constant
hydrogen			
iodine			
hydrogen iodide			

7.6

Under certain conditions, reversible reactions can reach equilibrium.

Equilibrium can be shifted by changing conditions.

Match each of the following changes to the effect it will have on the position of equilibrium.

Change

Increasing temperature

Decreasing pressure

Increasing pressure

Decreasing temperature

Effect on equilibrium

Shifts to favour the exothermic reaction.

Shifts to the side with fewer molecules of gas.

Shifts to favour the endothermic reaction.

Shifts to the side with more molecules of gas.

7.7

This reaction shows the Haber process.



The forward reaction is exothermic.

a) How would an increase in temperature affect the yield of ammonia at equilibrium?

The yield would
increase ☐

The yield would
decrease ☐

The yield would
be unaffected ☐

b) Give a reason for your answer.

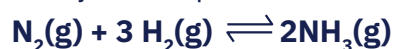
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.....

7.8

Nitrogen gas and hydrogen gas react to produce ammonia.

This is the symbol equation for the reaction:



In a sealed container, this reaction reaches equilibrium.

Complete the sentences to explain how you could increase the amount of ammonia formed.

Choose from the words:

decrease, increase, left, maintain, right, reversible

The side of the reaction that produces more molecules of gas is the side.

Therefore, to increase the amount of ammonia formed, you could the
pressure in the container.

7.9

The equation shows the production of hydrogen from steam.



More steam is added to the reaction chamber. The pressure is kept constant.

Complete the sentences to explain what happens to the equilibrium position and mixture.

Choose from the words:

catalysts, decrease, equilibrium, increase, left, products, reactants, reversible, right

Adding steam increases the concentration of

This shifts the equilibrium position to the

This will cause more to form. This therefore causes the amount

of hydrogen present in the equilibrium mixture to

7.10

Hydrogen and iodine react in a reversible reaction:



Explain the effect of adding a catalyst on the equilibrium position of this reaction.

.....

.....

.....

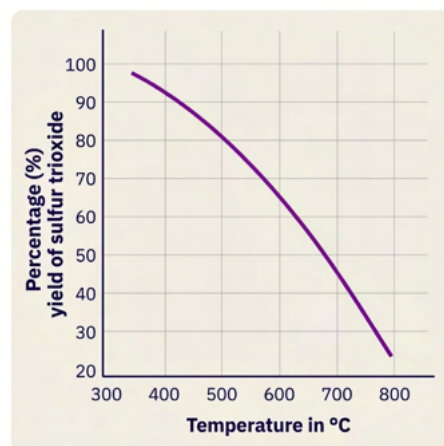
.....

7.11

Sulfur trioxide can be produced from sulfur dioxide and oxygen in a reversible reaction.



The graph shows how the percentage yield of sulfur trioxide depends on the temperature of the reaction container.



a) Is the forward reaction endothermic or exothermic?

Endothermic

☐

Exothermic

☐

b) Explain your answer.

.....

.....

.....

.....

Acids and alkalis

R529

1.1

Acids and alkalis produce particular ions.

a) What type of ions do acids produce in solution?

.....

b) What type of ions do alkalis produce in solution?

.....

1.2

Acids and alkalis react to produce water.

a) Complete the equation to show the reacting ions.



b) Give the name for the type of reaction shown by this equation.

.....

1.3

This shows the ionic equation for a reaction between two substances.



What evidence is there that shows an acid was involved in the reaction?

.....

.....

Concentrations of acids and alkalis

R309

2.1

The table shows how the pH value of an acid changes with its hydrogen ion concentration.

Predict the pH of an acid with a hydrogen ion concentration of 0.000 001 mol/dm³.

Use the pattern in the table to help you.

.....

pH	Hydrogen ion concentration (mol/dm ³)
0	1
1	0.1
2	0.01
3	0.001
4	0.000 1

- 2.2** During a neutralisation reaction, the pH of a mixture changed from 3 to 7.
By what factor did the concentration of the hydrogen ions in this mixture change?

.....

- 2.3** Hydrochloric acid is a strong acid that fully dissociates in water.
Hydrochloric acid with a concentration of $1.0 \times 10^{-4} \text{ mol/dm}^3$ has a pH of 4.0.
What is the pH of a $1.0 \times 10^{-6} \text{ mol/dm}^3$ solution of hydrochloric acid?

.....

- 2.4** Hydrochloric acid fully dissociates in water, producing hydrogen ions.
Solid hydrogen chloride is dissolved in a solution of hydrochloric acid.
The hydrogen ion concentration increases by a factor of 1000.
By how much does the pH change?

.....

- 2.5** A solution of nitric acid has a hydrogen ion concentration of 1.0 mol/dm^3 .
The nitric acid is diluted with water until the pH increases by 1 unit.
What is the new hydrogen ion concentration of the nitric acid after the water has been added?

..... mol/dm^3

2.6

A student measured 50 cm³ of an acid into a beaker and measured its pH. They then added distilled water to create a final volume of 500 cm³. Calculate the pH after dilution.

	Volume of acid (cm ³)	pH
Before dilution	50	2
After dilution	500	?

.....

Strong and weak acids

R629

3.1

Complete these definitions of different types of acids.

An acid that completely ionises in solution is known as a acid.

An acid that partially ionises in solution is known as a acid.

3.2

A student makes a sample of hydrochloric acid by dissolving 1 g of hydrogen chloride in 1000 cm³ of water. Which statement describes the acid?

A dilute solution
of a strong acid ☐

A concentrated solution
of a strong acid ☐

A concentrated solution
of a weak acid ☐

A dilute solution of
a weak acid ☐

3.3

This equation shows the dissociation of ethanoic acid in solution.



Explain how this equation shows that ethanoic acid is a **weak** acid.

.....

.....

.....

.....

3.4

The table gives information about two acids.

Formula of acid	Concentration (mol/dm ³)	Percentage of acid molecules ionised	pH value
HCl	0.2	100	1
HCOOH	0.5	4	2

Use data from the table to explain why the pH of the HCl solution is lower than the pH of HCOOH solution.

.....

.....

.....

.....

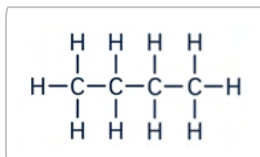
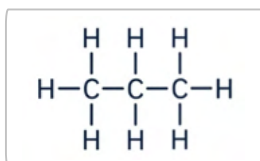
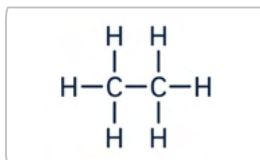
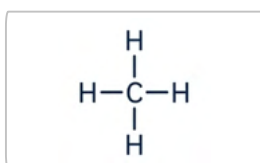
Crude oil

Z908

- 1.1** Alkanes contain only two elements.
Name these two elements.

..... and

- 1.2** The first four molecules in the homologous series of alkanes are shown.
Match each molecule to the correct name.

Molecule**Name**

Methane

Ethane

Butane

Propane

Fractional distillation of crude oil

R205

- 2.1** Crude oil is a mixture of hydrocarbons.
a) Name the process used to separate this mixture into different hydrocarbon fuels.

.....

- b) Which property of the hydrocarbons allows the mixture to be separated in this way?

Colour

Density

Reactivity

Boiling point

2.2

The table shows the boiling points of some different alkanes found in crude oil.

Alkane	Number of carbon atoms	Boiling point (°C)
Butane	4	-1
Pentane	5	36
Hexane	6	69
Heptane	7	98
Octane	8	126

- a) Describe the relationship between the number of carbon atoms in an alkane and its boiling point.

.....

.....

- b) Octane will condense lower in a fractionating column than the other alkanes in the table. Use your understanding of the temperature gradient in the fractionating column to explain why.

.....

.....

.....

.....

2.3

Crude oil is separated into different fractions in a fractionating column. The crude oil enters the column as a mixture of gases. Explain how the different fractions are separated in the column.

.....

.....

.....

.....

Cracking

Z766

- 3.1** Large alkane molecules in crude oil are cracked to produce more useful molecules.
Give **two** conditions used to crack large alkane molecules.

.....

.....

.....

- 3.2** Decane, $C_{10}H_{22}$, is a hydrocarbon.
It can be cracked into smaller molecules: $C_{10}H_{22} \rightarrow C_8H_{18} + ?$
What is the formula of the missing alkene in the equation?

.....

Combustion of fuels and pollution

R221, R119

- 4.1** Hydrocarbons take part in combustion reactions.
a) Name the gas that hydrocarbons react with during combustion reactions.

.....

- b) Name the two products formed from the complete combustion of hydrocarbons.

..... and

- 4.2** This symbol equation shows the combustion of propane.



- a) Name the type of combustion shown in the symbol equation.

.....

- b) Name **one** other product that is typically produced by this type of combustion.

.....

4.3

Carbon particulates are a form of atmospheric pollutant.

a) Complete this sentence to describe when carbon particulates would be produced.

Carbon particulates are produced when hydrocarbons undergo

incomplete

b) Which of these problems are caused by carbon particulates (soot) in the atmosphere?

Tick **all** that apply.

Blackening of
buildings

☐

Headaches

☐

Global dimming

☐

Respiratory problems

☐

Erosion of
statues

☐

4.4

Hydrocarbon fuels sometimes contain sulfur impurities.

a) Name the gas produced when sulfur impurities react during the combustion of fuels.

.....

b) This gas can dissolve in rainwater.

Name the environmental problem that this causes.

.....

4.5

Nitrogen oxides are formed inside car engines at high temperatures.

Describe what happens to nitrogen to form nitrogen oxides.

.....

.....

4.6

Petrol is produced to have an ultra-low sulfur content.
Explain why sulfur is removed from petrol.

.....

.....

.....

.....

4.7

Some power stations burn coal mixed with calcium carbonate.
One of the reactions that takes place is shown below:



a) Explain **one** way in which this reaction helps to **reduce** atmospheric pollution.

.....

.....

.....

.....

b) Explain **one** way in which this reaction **increases** atmospheric pollution.

.....

.....

.....

.....

1.1

A student is setting up a chromatography experiment. They need to draw a line on their paper to show where to put a spot of the mixture.

a) What should the student use to draw the line?

.....

b) Give a reason for your answer.

.....

.....



1.2

During chromatography

a) which of these is the **mobile** phase?

beaker ☐ chromatography paper ☐ ink ☐

pencil line ☐ solvent ☐

b) which of these is the **stationary** phase?

beaker ☐ chromatography paper ☐ ink ☐

pencil line ☐ solvent ☐

1.3

A student carries out chromatography on a mixture.

Which of the following would change the distance that substances in the mixture travel up the paper?

Using a larger volume of mixture ☐

Using a different solvent ☐

Drawing the start line with a different pencil ☐

Using a different volume of solvent ☐

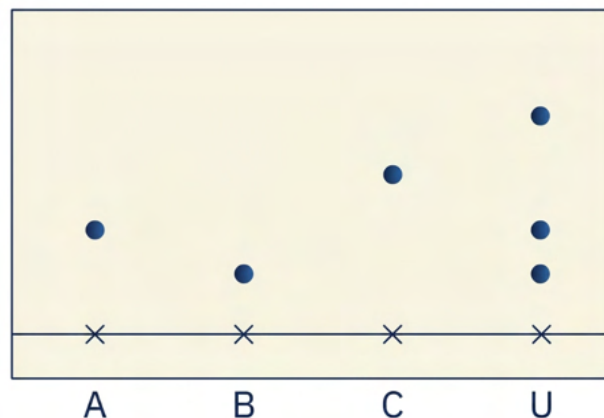
1.4

A student carried out paper chromatography on three known inks (A, B and C) and one unknown mixture of inks (U).

Their chromatogram is shown.

Which of inks A, B and C were in the unknown mixture, U?

A ☐ B ☐ C ☐



1.5

In a paper chromatography experiment, a substance moved 60 mm up the paper.

The solvent moved 80 mm.

Calculate the R_f value of the substance.

.....

Distillation

R550

2.1

A mixture of ethanol and water can be separated using fractional distillation.

a) Which substance will evaporate first?

Ethanol ☐ Water ☐

Substance	Boiling point (°C)
Ethanol	78
Water	100

b) After evaporating, what change of state needs to occur for this substance to be collected?

.....

2.2

This image shows a student's distillation set-up.

They forget to turn on the cold water supply to the condenser.

How will this affect their distillation?

.....

.....

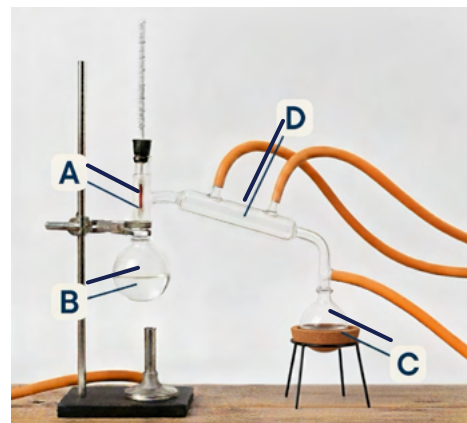
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2.3 The diagram shows the experimental set-up for distillation.

- a) Tick one box in each row of the table to show the state of any substances present at locations A, B and C.

Location	State		
	Solid	Liquid	Gas
A			
B			
C			



- b) Which change of state is occurring at D?

.....

2.4 In a process to make nickel, a mixture of liquid nickel tetracarbonyl and liquid iron pentacarbonyl is made.

- The boiling point of nickel tetracarbonyl is 43°C .
- The boiling point of iron pentacarbonyl is 103°C .

These two liquids mix together completely and can be separated using distillation. Suggest a temperature you should heat the mixture to, to allow you to separate the liquids using distillation.

..... $^{\circ}\text{C}$