

The Periodic Table of the Elements

1	2	3	4	5	6	7	0	
7 Li lithium 3	9 Be beryllium 4	11 Na sodium 11	12 C carbon 6	13 Al aluminium 13	14 N nitrogen 7	15 O oxygen 8	16 F fluorine 9	17 Ne neon 10
19 K potassium 19	20 Ca calcium 20	23 Sc scandium 21	24 Ti titanium 22	25 V vanadium 23	26 Cr chromium 24	27 Mn manganese 25	28 Fe iron 26	29 Co cobalt 27
37 Rb rubidium 37	38 Sr strontium 38	39 Y yttrium 39	40 Zr zirconium 40	41 Nb niobium 41	42 Mo molybdenum 42	43 Tc technetium 43	44 Ru ruthenium 44	45 Rh rhodium 45
55 Cs caesium 55	56 Ba barium 56	57 La* lanthanum 57	58 Hf hafnium 58	59 Ta tantalum 59	60 W tungsten 60	61 Re rhenium 61	62 Os osmium 62	63 Ir iridium 63
87 Fr francium 87	88 Ra radium 88	89 Ac* actinium 89	90 Rf rutherfordium 90	91 Db dubnium 91	92 Sg seaborgium 92	93 Bh bohrium 93	94 Hs hassium 94	95 Mt meitnerium 95
133 Cs caesium 133	137 Ba barium 137	138 La* lanthanum 138	139 Hf hafnium 139	140 Ta tantalum 140	141 W tungsten 141	142 Re rhenium 142	143 Os osmium 143	144 Ir iridium 144
187 Rb rubidium 187	188 Sr strontium 188	189 Y yttrium 189	190 Zr zirconium 190	191 Nb niobium 191	192 Mo molybdenum 192	193 Tc technetium 193	194 Ru ruthenium 194	195 Rh rhodium 195
223 Fr francium 223	226 Ra radium 226	227 Ac* actinium 227	228 Rf rutherfordium 228	229 Db dubnium 229	230 Sg seaborgium 230	231 Bh bohrium 231	232 Hs hassium 232	233 Mt meitnerium 233
285 Cs caesium 285	286 Ba barium 286	287 La* lanthanum 287	288 Hf hafnium 288	289 Ta tantalum 289	290 W tungsten 290	291 Re rhenium 291	292 Os osmium 292	293 Ir iridium 293
337 Rb rubidium 337	338 Sr strontium 338	339 Y yttrium 339	340 Zr zirconium 340	341 Nb niobium 341	342 Mo molybdenum 342	343 Tc technetium 343	344 Ru ruthenium 344	345 Rh rhodium 345
397 Cs caesium 397	398 Ba barium 398	399 La* lanthanum 399	400 Hf hafnium 400	401 Ta tantalum 401	402 W tungsten 402	403 Re rhenium 403	404 Os osmium 404	405 Ir iridium 405
449 Rb rubidium 449	450 Sr strontium 450	451 Y yttrium 451	452 Zr zirconium 452	453 Nb niobium 453	454 Mo molybdenum 454	455 Tc technetium 455	456 Ru ruthenium 456	457 Rh rhodium 457
503 Cs caesium 503	504 Ba barium 504	505 La* lanthanum 505	506 Hf hafnium 506	507 Ta tantalum 507	508 W tungsten 508	509 Re rhenium 509	510 Os osmium 510	511 Ir iridium 511
559 Rb rubidium 559	560 Sr strontium 560	561 Y yttrium 561	562 Zr zirconium 562	563 Nb niobium 563	564 Mo molybdenum 564	565 Tc technetium 565	566 Ru ruthenium 566	567 Rh rhodium 567
609 Cs caesium 609	610 Ba barium 610	611 La* lanthanum 611	612 Hf hafnium 612	613 Ta tantalum 613	614 W tungsten 614	615 Re rhenium 615	616 Os osmium 616	617 Ir iridium 617
675 Rb rubidium 675	676 Sr strontium 676	677 Y yttrium 677	678 Zr zirconium 678	679 Nb niobium 679	680 Mo molybdenum 680	681 Tc technetium 681	682 Ru ruthenium 682	683 Rh rhodium 683
729 Cs caesium 729	730 Ba barium 730	731 La* lanthanum 731	732 Hf hafnium 732	733 Ta tantalum 733	734 W tungsten 734	735 Re rhenium 735	736 Os osmium 736	737 Ir iridium 737
791 Rb rubidium 791	792 Sr strontium 792	793 Y yttrium 793	794 Zr zirconium 794	795 Nb niobium 795	796 Mo molybdenum 796	797 Tc technetium 797	798 Ru ruthenium 798	799 Rh rhodium 799
839 Cs caesium 839	840 Ba barium 840	841 La* lanthanum 841	842 Hf hafnium 842	843 Ta tantalum 843	844 W tungsten 844	845 Re rhenium 845	846 Os osmium 846	847 Ir iridium 847
895 Rb rubidium 895	896 Sr strontium 896	897 Y yttrium 897	898 Zr zirconium 898	899 Nb niobium 899	900 Mo molybdenum 900	901 Tc technetium 901	902 Ru ruthenium 902	903 Rh rhodium 903
949 Cs caesium 949	950 Ba barium 950	951 La* lanthanum 951	952 Hf hafnium 952	953 Ta tantalum 953	954 W tungsten 954	955 Re rhenium 955	956 Os osmium 956	957 Ir iridium 957
1013 Rb rubidium 1013	1014 Sr strontium 1014	1015 Y yttrium 1015	1016 Zr zirconium 1016	1017 Nb niobium 1017	1018 Mo molybdenum 1018	1019 Tc technetium 1019	1020 Ru ruthenium 1020	1021 Rh rhodium 1021
1063 Cs caesium 1063	1064 Ba barium 1064	1065 La* lanthanum 1065	1066 Hf hafnium 1066	1067 Ta tantalum 1067	1068 W tungsten 1068	1069 Re rhenium 1069	1070 Os osmium 1070	1071 Ir iridium 1071
1113 Rb rubidium 1113	1114 Sr strontium 1114	1115 Y yttrium 1115	1116 Zr zirconium 1116	1117 Nb niobium 1117	1118 Mo molybdenum 1118	1119 Tc technetium 1119	1120 Ru ruthenium 1120	1121 Rh rhodium 1121
1163 Cs caesium 1163	1164 Ba barium 1164	1165 La* lanthanum 1165	1166 Hf hafnium 1166	1167 Ta tantalum 1167	1168 W tungsten 1168	1169 Re rhenium 1169	1170 Os osmium 1170	1171 Ir iridium 1171
1213 Rb rubidium 1213	1214 Sr strontium 1214	1215 Y yttrium 1215	1216 Zr zirconium 1216	1217 Nb niobium 1217	1218 Mo molybdenum 1218	1219 Tc technetium 1219	1220 Ru ruthenium 1220	1221 Rh rhodium 1221
1263 Cs caesium 1263	1264 Ba barium 1264	1265 La* lanthanum 1265	1266 Hf hafnium 1266	1267 Ta tantalum 1267	1268 W tungsten 1268	1269 Re rhenium 1269	1270 Os osmium 1270	1271 Ir iridium 1271
1313 Rb rubidium 1313	1314 Sr strontium 1314	1315 Y yttrium 1315	1316 Zr zirconium 1316	1317 Nb niobium 1317	1318 Mo molybdenum 1318	1319 Tc technetium 1319	1320 Ru ruthenium 1320	1321 Rh rhodium 1321
1363 Cs caesium 1363	1364 Ba barium 1364	1365 La* lanthanum 1365	1366 Hf hafnium 1366	1367 Ta tantalum 1367	1368 W tungsten 1368	1369 Re rhenium 1369	1370 Os osmium 1370	1371 Ir iridium 1371
1413 Rb rubidium 1413	1414 Sr strontium 1414	1415 Y yttrium 1415	1416 Zr zirconium 1416	1417 Nb niobium 1417	1418 Mo molybdenum 1418	1419 Tc technetium 1419	1420 Ru ruthenium 1420	1421 Rh rhodium 1421
1463 Cs caesium 1463	1464 Ba barium 1464	1465 La* lanthanum 1465	1466 Hf hafnium 1466	1467 Ta tantalum 1467	1468 W tungsten 1468	1469 Re rhenium 1469	1470 Os osmium 1470	1471 Ir iridium 1471
1513 Rb rubidium 1513	1514 Sr strontium 1514	1515 Y yttrium 1515	1516 Zr zirconium 1516	1517 Nb niobium 1517	1518 Mo molybdenum 1518	1519 Tc technetium 1519	1520 Ru ruthenium 1520	1521 Rh rhodium 1521
1563 Cs caesium 1563	1564 Ba barium 1564	1565 La* lanthanum 1565	1566 Hf hafnium 1566	1567 Ta tantalum 1567	1568 W tungsten 1568	1569 Re rhenium 1569	1570 Os osmium 1570	1571 Ir iridium 1571
1613 Rb rubidium 1613	1614 Sr strontium 1614	1615 Y yttrium 1615	1616 Zr zirconium 1616	1617 Nb niobium 1617	1618 Mo molybdenum 1618	1619 Tc technetium 1619	1620 Ru ruthenium 1620	1621 Rh rhodium 1621
1663 Cs caesium 1663	1664 Ba barium 1664	1665 La* lanthanum 1665	1666 Hf hafnium 1666	1667 Ta tantalum 1667	1668 W tungsten 1668	1669 Re rhenium 1669	1670 Os osmium 1670	1671 Ir iridium 1671
1713 Rb rubidium 1713	1714 Sr strontium 1714	1715 Y yttrium 1715	1716 Zr zirconium 1716	1717 Nb niobium 1717	1718 Mo molybdenum 1718	1719 Tc technetium 1719	1720 Ru ruthenium 1720	1721 Rh rhodium 1721
1763 Cs caesium 1763	1764 Ba barium 1764	1765 La* lanthanum 1765	1766 Hf hafnium 1766	1767 Ta tantalum 1767	1768 W tungsten 1768	1769 Re rhenium 1769	1770 Os osmium 1770	1771 Ir iridium 1771
1813 Rb rubidium 1813	1814 Sr strontium 1814	1815 Y yttrium 1815	1816 Zr zirconium 1816	1817 Nb niobium 1817	1818 Mo molybdenum 1818	1819 Tc technetium 1819	1820 Ru ruthenium 1820	1821 Rh rhodium 1821
1863 Cs caesium 1863	1864 Ba barium 1864	1865 La* lanthanum 1865	1866 Hf hafnium 1866	1867 Ta tantalum 1867	1868 W tungsten 1868	1869 Re rhenium 1869	1870 Os osmium 1870	1871 Ir iridium 1871
1913 Rb rubidium 1913	1914 Sr strontium 1914	1915 Y yttrium 1915	1916 Zr zirconium 1916	1917 Nb niobium 1917	1918 Mo molybdenum 1918	1919 Tc technetium 1919	1920 Ru ruthenium 1920	1921 Rh rhodium 1921
1963 Cs caesium 1963	1964 Ba barium 1964	1965 La* lanthanum 1965	1966 Hf hafnium 1966	1967 Ta tantalum 1967	1968 W tungsten 1968	1969 Re rhenium 1969	1970 Os osmium 1970	1971 Ir iridium 1971
2013 Rb rubidium 2013	2014 Sr strontium 2014	2015 Y yttrium 2015	2016 Zr zirconium 2016	2017 Nb niobium 2017	2018 Mo molybdenum 2018	2019 Tc technetium 2019	2020 Ru ruthenium 2020	2021 Rh rhodium 2021
2063 Cs caesium 2063	2064 Ba barium 2064	2065 La* lanthanum 2065	2066 Hf hafnium 2066	2067 Ta tantalum 2067	2068 W tungsten 2068	2069 Re rhenium 2069	2070 Os osmium 2070	2071 Ir iridium 2071
2113 Rb rubidium 2113	2114 Sr strontium 2114	2115 Y yttrium 2115	2116 Zr zirconium 2116	2117 Nb niobium 2117	2118 Mo molybdenum 2118	2119 Tc technetium 2119	2120 Ru ruthenium 2120	2121 Rh rhodium 2121
2163 Cs caesium 2163	2164 Ba barium 2164	2165 La* lanthanum 2165	2166 Hf hafnium 2166	2167 Ta tantalum 2167	2168 W tungsten 2168	2169 Re rhenium 2169	2170 Os osmium 2170	2171 Ir iridium 2171
2213 Rb rubidium 2213	2214 Sr strontium 2214	2215 Y yttrium 2215	2216 Zr zirconium 2216	2217 Nb niobium 2217	2218 Mo molybdenum 2218	2219 Tc technetium 2219	2220 Ru ruthenium 2220	2221 Rh rhodium 2221
2263 Cs caesium 2263	2264 Ba barium 2264	2265 La* lanthanum 2265	2266 Hf hafnium 2266	2267 Ta tantalum 2267	2268 W tungsten 2268	2269 Re rhenium 2269	2270 Os osmium 2270	2271 Ir iridium 2271
2313 Rb rubidium 2313	2314 Sr strontium 2314	2315 Y yttrium 2315	2316 Zr zirconium 2316	2317 Nb niobium 2317	2318 Mo molybdenum 2318	2319 Tc technetium 2319	2320 Ru ruthenium 2	

Answer ALL questions.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Sodium hydroxide solution can be used to test for positive ions.

(a) Sodium hydroxide solution produces a coloured precipitate when added to a solution of iron ions.

Draw one straight line from each iron ion to the colour of the precipitate.

(2)

Iron ion	Colour of the precipitate
<div style="border: 1px solid black; padding: 5px; display: inline-block;">Fe²⁺</div>	<div style="border: 1px solid black; padding: 5px; display: inline-block;">blue</div>
<div style="border: 1px solid black; padding: 5px; display: inline-block;">Fe³⁺</div>	<div style="border: 1px solid black; padding: 5px; display: inline-block;">brown</div>
	<div style="border: 1px solid black; padding: 5px; display: inline-block;">green</div>
	<div style="border: 1px solid black; padding: 5px; display: inline-block;">lilac</div>
	<div style="border: 1px solid black; padding: 5px; display: inline-block;">yellow</div>

(b) Sodium hydroxide solution is used to test for ammonium ions.

A gas is produced from the reaction.

The identity of this gas is confirmed using damp red litmus paper.

Explain the result of this test.

(3)

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(Total for Question 1 = 5 marks)



2 The element sodium is in Group 1 of the Periodic Table.

(a) When sodium reacts with water, a gas is given off.

(i) The gas gives a squeaky pop when ignited with a lit splint.

Identify the gas.

(1)

(ii) Give one difference in the reaction with water if lithium is used instead of sodium.

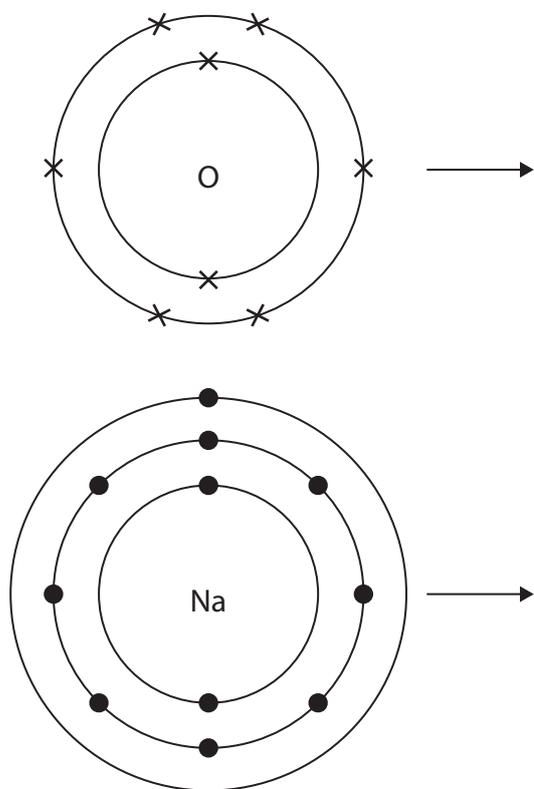
(1)

(b) Sodium reacts with oxygen to form the ionic compound sodium oxide.

(i) Complete the dot-and-cross diagram for the formation of the two ions in sodium oxide.

Include the charge on each ion.

(2)



(ii) Give a chemical equation for the reaction between sodium and oxygen.

(2)

(iii) Explain, in terms of structure and bonding, why sodium oxide has a high melting point.

(3)

(Total for Question 2 = 9 marks)

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P 8 1 5 6 0 R A 0 7 2 8

4 Electrolysis is the decomposition of a substance using an electric current.

(a) Which row of the table is correct for the electrolysis of an ionic compound?

(1)

	Electrolysis occurs when molten	Electrolysis occurs when solid
<input type="checkbox"/> A	no	no
<input type="checkbox"/> B	no	yes
<input type="checkbox"/> C	yes	no
<input type="checkbox"/> D	yes	yes

(b) A student does an experiment involving the electrolysis of aqueous copper(II) sulfate solution using inert electrodes.

(i) Draw a labelled diagram for this experiment.

(2)



(ii) Describe the observations seen at each electrode during the experiment.

(2)

negative electrode

positive electrode

(iii) Give the ionic half-equation for the reduction reaction in this electrolysis.

(1)

(Total for Question 4 = 6 marks)

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- 5 A student investigates the rate of reaction between marble chips and dilute hydrochloric acid.

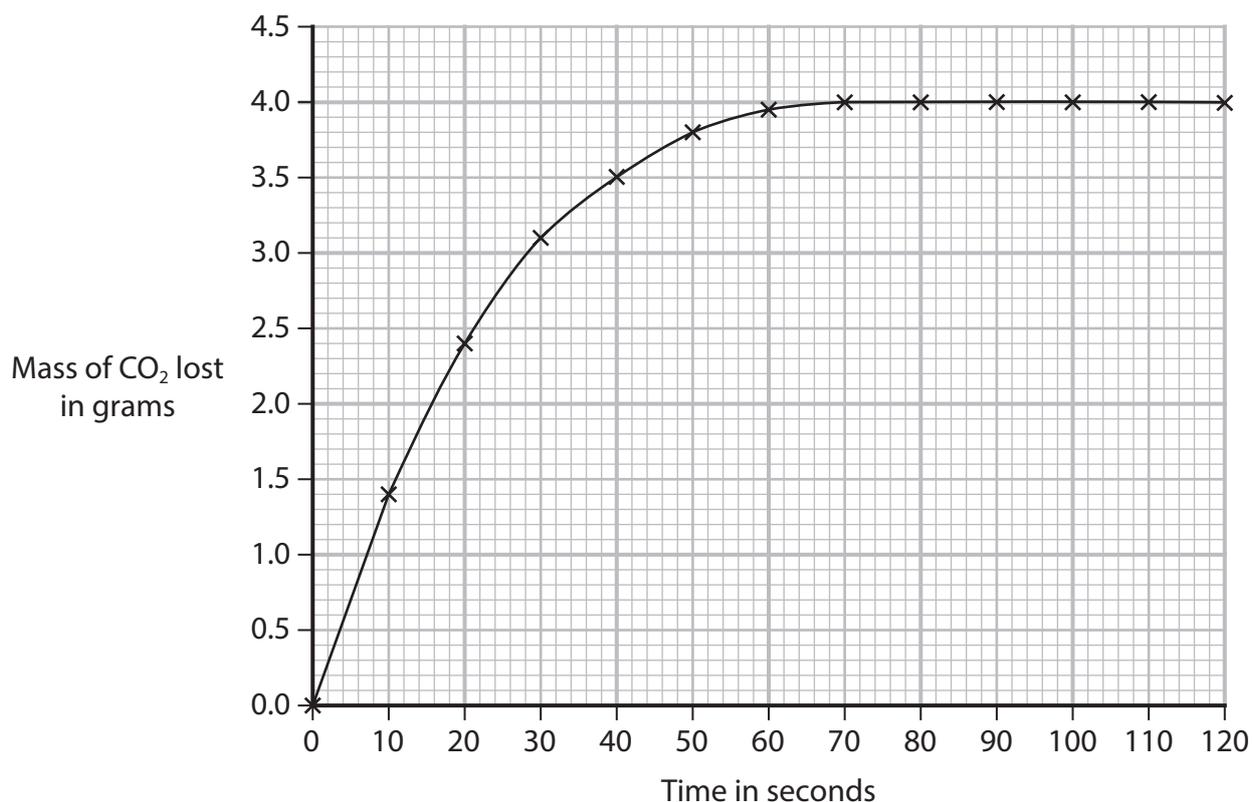
The equation for the reaction is shown.



The marble chips are small and the acid has a concentration of 2.0 mol/dm^3 .

- (a) The student records the mass of CO_2 lost from the reaction mixture every 10 seconds until there is no further change in mass.

The graph shows the student's results.



Calculate the mean rate of reaction, in g/s, between 10 seconds and 30 seconds.

(2)

mean rate of reaction = g/s



- (b) The student repeats the experiment using larger marble chips but does not change the mass of the chips or the concentration of the acid.

The table shows the student's results.

Time in seconds	0	10	20	30	40	50	60	70	80	90	100
Mass of CO₂ lost in grams	0.00	0.70	1.30	1.90	2.40	2.85	3.25	3.55	3.75	3.90	4.00

- (i) Plot these results on the graph in part (a). (1)
- (ii) Draw a curve of best fit. (1)
- (iii) Explain how using larger marble chips affects the rate of this reaction. (3)

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- (c) The student repeats the first experiment using the same mass of the small marble chips but using an acid concentration of 1.25 mol/dm³.

Sketch a curve on the graph in part (a) to show the effect of this change in concentration.

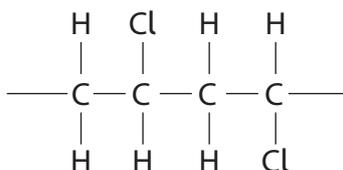
You should assume that the marble chips are in excess. (2)

(Total for Question 5 = 9 marks)



6 PVC is a polymer used in underground water pipes.

This is the displayed formula of two repeat units of PVC.



(a) Which is the empirical formula of PVC?

(1)

- A CHCl
- B C₂H₂Cl₂
- C C₂H₃Cl
- D C₄H₆Cl₂

(b) A polymer is formed from many small molecules which join together.

(i) Give the name for this type of small molecule.

(1)

(ii) Draw the displayed formula of the small molecule that forms PVC.

(1)



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(c) One method of disposing of PVC is by burning.

When PVC burns, hydrogen chloride (HCl) gas is formed.

(i) A sample of PVC produces 146 g of HCl gas.

1 mol of the PVC sample produces 2400 mol of HCl gas.

Calculate the mass, in g, of the PVC sample burned.

[for HCl $M_r = 36.5$]

[for PVC $M_r = 150\,000$]

(3)

mass of the PVC sample = g

(ii) Give one problem caused by the release of hydrogen chloride gas into the atmosphere.

(1)

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(iii) Another problem with the disposal of PVC is that PVC is an inert material.

Explain why this property is an advantage in underground water pipes.

(2)

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(Total for Question 6 = 9 marks)

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P 8 1 5 6 0 R A 0 1 3 2 8

7 (a) Steam can be used to manufacture ethanol.

(i) Give the other reactant needed for this reaction.

(1)

(ii) State the pressure and catalyst used for this reaction to manufacture ethanol.

(2)

pressure

catalyst

(b) The glucose in grapes can be fermented to make ethanol.

(i) State the condition needed to prevent the formation of ethanoic acid.

(1)

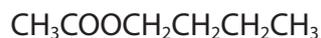
(ii) Explain why fermentation needs to happen in the range of 30 °C to 40 °C.

(2)



(c) Grapes also contain esters.

This is the structural formula of an ester.



(i) Draw the displayed formula of this ester.

(2)

(ii) Deduce the name of the carboxylic acid and the name of the alcohol that react to form this ester.

(2)

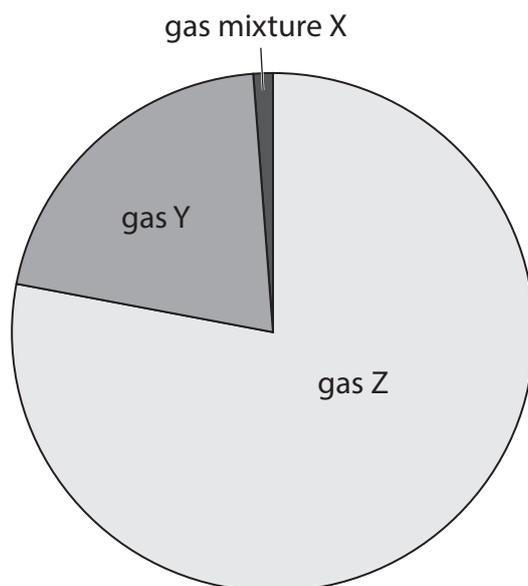
carboxylic acid

alcohol

(Total for Question 7 = 10 marks)



- 8 The pie chart shows the approximate proportions by volume of the main gases in dry air at room temperature and pressure.



- (a) (i) Name the most abundant gas in gas mixture X.

(1)

- (ii) Gas mixture X also contains carbon dioxide.

Give one problem caused by an increasing amount of carbon dioxide in the Earth's atmosphere.

(1)

- (iii) What is the approximate volume of gas Z in 150 cm^3 of dry air?

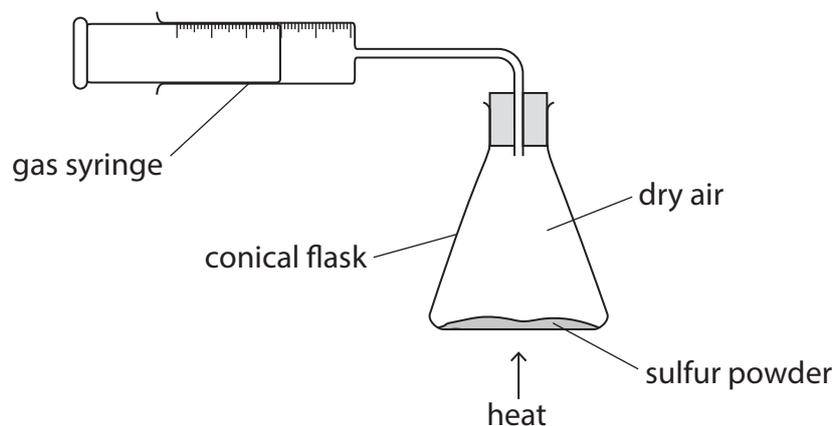
(1)

- A 80 cm^3
- B 100 cm^3
- C 120 cm^3
- D 140 cm^3



(b) A teacher heats some sulfur powder in a sample of dry air.

The diagram shows the teacher's apparatus.



After heating stops, the contents of the conical flask return to room temperature.

Explain why the reading on the gas syringe is unchanged.

Include a chemical equation in your answer.

(3)

(Total for Question 8 = 6 marks)



9 A student wants to confirm that a solid is hydrated copper(II) sulfate.

(a) The student tests for sulfate ions.

This is the student's method.

- dissolve some of the solid in water to make a solution
- add a few drops of acidified barium chloride solution

The student's observation confirms that the solid contains sulfate ions.

(i) Give the student's observation for this test.

(1)

(ii) Complete the chemical equation for the reaction between copper(II) sulfate and barium chloride.

Include state symbols.

(2)



(b) The student confirms that copper(II) ions are present in the solid by doing a flame test.

Describe the method and result for this flame test.

(3)

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(c) The student heats the solid hydrated copper(II) sulfate.

The solid changes in colour and a colourless liquid is also produced.

(i) The student decides to do a physical test to confirm that the colourless liquid is water.

Give a physical test that could be used to confirm that the liquid is water.

(2)

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(ii) The student concludes that heating the solid results in the formation of anhydrous copper(II) sulfate and that the reaction is reversible.

Describe how the student could demonstrate that the reaction is reversible.

(2)

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(iii) Give a word equation to show that heating hydrated copper(II) sulfate is a reversible reaction.

(1)

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(d) The formula of hydrated copper(II) sulfate is $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$

The student wants to find the value of x in the formula.

A sample of hydrated copper(II) sulfate is placed in a test tube and heated to remove all of the water.

The mass of the sample before and after heating is recorded.

The table shows the student's results.

	Mass in g
Empty test tube	20.50
Test tube and $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$	26.74
Test tube and CuSO_4	24.49

Show that the value of x in the formula $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$ is 5

[for CuSO_4 $M_r = 159.5$]

[for H_2O $M_r = 18$]

(5)

(Total for Question 9 = 16 marks)



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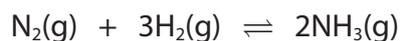
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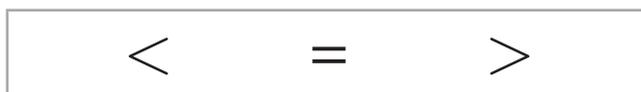
10 The equation shows the reaction to produce ammonia.



Iron is used to increase the rate of the reaction.

A scientist obtains a percentage yield of 70% of ammonia when the reaction reaches equilibrium in a sealed container.

(a) (i) The box shows three mathematical symbols.

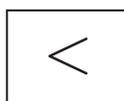


Complete the statements about the reaction, using each mathematical symbol once, more than once, or not at all.

The first statement has been completed for you.

(1)

rate of reaction without iron



rate of reaction with iron

amount of product at equilibrium



amount of reactants at equilibrium

rate of forward reaction at equilibrium



rate of reverse reaction at equilibrium

(ii) The rate of reaction decreases when iron is removed from the sealed container.

Explain why the rate of reaction decreases.

(3)

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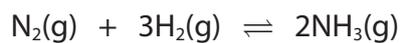


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(b) The equation shows the reaction to produce ammonia.



The mass of nitrogen gas used in the reaction is 5100 g.

The percentage yield of ammonia from this reaction is 70%.

Calculate the mass of ammonia produced in this reaction.

[for N_2 $M_r = 28$]

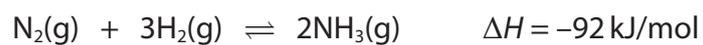
[for NH_3 $M_r = 17$]

(4)

mass of ammonia = g



(c) The production of ammonia is shown in the equation.



The scientist changes the conditions of pressure and temperature.

The table shows these changes.

	Pressure in atm	Temperature in °C
Original conditions	400	400
New conditions	300	500



Discuss how the new conditions will change the percentage yield of ammonia.

(6)

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(Total for Question 10 = 14 marks)

TOTAL FOR PAPER = 90 MARKS



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