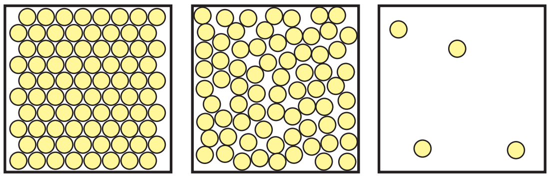
CHEMISTRY

UNIT 1 ANSWERS

CHAPTER 1

1 ▶ a Melting b Freezing
c Subliming / sublimation

2 ▶ a



Note: Solids should have regularly packed particles touching. Liquids should have most of the particles touching at least some of their neighbours, but with gaps here and there, and no regularity. Gases should have the particles well spaced.

b Solids: vibration around a fixed point. Liquids: particles can move around each other.

c Evaporation can occur at any temperature; boiling can only occur at the boiling point. Boiling: bubbling; evaporation: no bubbling.

3 ▶ a i A – gas; B – liquid; C – solid; D – liquid; E – solid
ii A – gas; B – solid; C – solid; D – liquid; E – solid
iii A – gas; B – liquid; C – solid; D – gas; E – solid

b A, because it is a gas.

c It sublimes and therefore is converted directly from a solid to a gas without going through the liquid stage.

d D – it has a lower boiling point than substance B (the only other substance that is a liquid at 25 °C), so the forces of attraction between particles will be weaker and it will evaporate more easily.

4 ▶ a The ammonia and hydrogen chloride particles have to diffuse through the air in the tube, colliding with air particles all the way.

b i Its particles will move faster.
ii It would take slightly longer for the white ring to form, because the gas particles would be moving more slowly at the lower temperature.

c Ammonia particles are lighter than hydrogen chloride particles and so move faster. The ammonia covers more distance than the hydrogen chloride in the same time.

d i Ammonium bromide
ii The heavier hydrogen bromide particles would move more slowly than the hydrogen chloride particles, and so the ring would form even closer to the hydrobromic acid end than it was to the hydrochloric acid end. The ring will also take slightly longer to form because of the slower moving particles.

5 ▶ a The colour spreads out (slowly) to form a purple solution. If the beaker is left long enough, the colour should become uniform/constant throughout the beaker.

The two processes are dissolving and diffusion.

b The level of liquid will be lower and the colour will be more intense (same number of potassium manganate(VII) particles in a smaller volume); crystals may also form if the laboratory is warm enough for sufficient water to evaporate.

Evaporation / water has evaporated.

CHAPTER 2

1 ▶

Element	Compound	Mixture
hydrogen	magnesium oxide	seawater
calcium	copper(II) sulfate	honey
		blood
		mud
		potassium iodide solution

2 ▶ a Mixture b Mixture c Element
d Element e Compound f Compound

3 ▶ Substance X is the pure substance – it melts at a fixed temperature. Substance Y is impure – it melts over a range of temperatures.

4 ▶ a Crystallisation b (Simple) distillation
c Fractional distillation d Chromatography
e Filtration

5 ▶ For example: Stir with a large enough volume of water to dissolve all the sugar. Filter to leave the diamonds on the filter paper. Wash on the filter paper with distilled water to remove any last traces of sugar solution. Allow to dry.

6 ▶ a M b R
c 0.45 ±0.01 (measure to the centre of the spot and remember to measure from the base line and not from the bottom of the paper)
d G and T e P

CHAPTER 3

1 ▶ a The nucleus b Electrons
c Proton d Proton and neutron

2 ▶ a 9
b Sum of the number of protons + neutrons in the nucleus
c 9 p, 10 n, 9 e
d A proton and an electron have equal but opposite charges. The atom has no overall charge, therefore there must be equal numbers of protons and electrons.

3 ▶ D

4 ▶ a 26 p, 30 n, 26 e b 41 p, 52 n, 41 e
c 92 p, 143 n, 92 e

5 ▶ a Atoms with the same atomic number but different mass numbers. They have the same number of protons, but different numbers of neutrons.

b ^{35}Cl: 17 p, 18 n, 17 e; ^{37}Cl: 17 p, 20 n, 17 e

6 ▶ a Protons have a 1+ charge and electrons have a 1– charge. They all have the same number of protons and electrons so the charges cancel.

b Q and D

c 17

d 37

e $^{24}_{12}Q$

f The charge will now be 2+ as it has 2 more protons than electrons and protons have a positive charge.

There will be virtually no effect on the mass – the mass of an electron is negligible compared with the masses of protons and neutrons (the mass here would change by about 0.004%).

7 ▶ D

8 ▶ B

9 ▶ $\frac{6 \times 7 + 93 \times 7}{100} = 6.93$

10 ▶ $\frac{24 \times 78.99 + 25 \times 10.00 + 26 \times 11.01}{100} = 24.32$

11 ▶ $\frac{204 \times 1.4 + 206 \times 24.1 + 207 \times 22.1 + 208 \times 52.4}{100} = 207.24$

12 ▶ a 77 protons, 114 neutrons, 77 electrons

b Iridium-193 has 2 more neutrons in the nucleus.

c More iridium-193 because the relative atomic mass is closer to 193 than 191.

CHAPTER 4

1 ▶ a i Strontium ii Chlorine iii Nitrogen
iv Caesium v Neon

b Metals: caesium, molybdenum, nickel, strontium, tin
Non-metals: chlorine, neon, nitrogen

2 ▶ a Rubidium

b Gallium

3 ▶ a Z and R

b Q and Z

c 4

d M has a higher atomic number; the elements are arranged in the Periodic Table in order of increasing atomic number, and M is after A.

e A

4 ▶ a 33 b 35 c 50 d 54

5 ▶ Argon and potassium OR iodine and tellurium.
The elements would then be in a different group in the Periodic Table. They would react in a completely different way to the other members of the group. For example, potassium would be in Group 0 with the noble gases, and argon, which is very unreactive, would be in Group 1, with the highly reactive alkali metals.

6 ▶ This statement is true – it only applies to one element, hydrogen (^{1}H).

CHAPTER 5

1 ▶ a Sulfur dioxide, SO_2: 2

b Carbon disulfide, CS_2: 2

c Phosphorus trichloride, PCl_3: 2

d Silver nitrate, $AgNO_3$: 3

e Potassium dichromate, $K_2Cr_2O_7$: 3

f Nitrobenzene, $C_6H_5NO_2$: 4

2 ▶ a Phosphorus pentachloride PCl_5; phosphorus tribromide PBr_3

b XeF_2 xenon difluoride; XeF_4 xenon tetrafluoride; XeF_6 xenon hexafluoride

3 ▶ A: $POCl_3$ B: Cl_2O_7 C: $C_4H_8O_2$
The elements can be in any order.

4 ▶ a 4 b 3 c 11

5 ▶ a $Fe + 2HCl \rightarrow FeCl_2 + H_2$

b $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

c $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

d $2Al + Cr_2O_3 \rightarrow Al_2O_3 + 2Cr$

e $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

f $2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2CO_2 + 2H_2O$

g $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$

h $Fe_3O_4 + 4H_2 \rightarrow 3Fe + 4H_2O$

i $Pb + 2AgNO_3 \rightarrow Pb(NO_3)_2 + 2Ag$

j $2AgNO_3 + MgCl_2 \rightarrow Mg(NO_3)_2 + 2AgCl$

k $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

6 ▶ C

7 ▶ a i $H_2O(l)$

ii $H_2O(s)$

iii $CO_2(g)$

iv $CO_2(s)$

b i $H_2O(s) \rightarrow H_2O(l)$

ii $CO_2(s) \rightarrow CO_2(g)$

8 ▶ a $CuCO_3(s) \rightarrow CuO(s) + CO_2(g)$

b $Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4(aq)$

c $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

d $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$

9 ▶ a 40 b 44 c 17 d 111 e 60
f 142 g 132 h 392 i 286 j 404

CHAPTER 6

1 ▶ a An atom or group of atoms which has lost or gained electrons so that it has a positive or negative charge.

b Attractions between positively and negatively charged ions holding them together.

2 ▶ a 2+

b 3–

3 ▶

		a formula	b name
i	magnesium	Mg^{2+}	
ii	strontium	Sr^{2+}	
iii	potassium	K^{+}	
iv	oxygen	O^{2-}	oxide
v	sulfur	S^{2-}	sulfide
vi	caesium	Cs^{+}	
vii	chlorine	Cl^{-}	chloride
viii	iodine	I^{-}	iodide
ix	aluminium	Al^{3+}	
x	calcium	Ca^{2+}	
xi	nitrogen	N^{3-}	nitride

4 ▶ a X gains 1 electron therefore the ion has a 1– charge.

b X is a non-metal because it forms a negative ion. Non-metals form negative ions but metals form positive ions.

c Group 7; only the atoms in Group 7 form 1– ions

5 ▶ a $MgSO_4$
b K_2CO_3
c $Ca(NO_3)_2$
d $Al_2(SO_4)_3$
e $CoCl_2$
f NH_4NO_3
g Na_2SO_4
h NaBr
i $(NH_4)_2S$
j $Ca(OH)_2$
k CaO
l RbI

6 ▶ a Lithium chloride
b Lithium nitride
c Lithium sulfate
d Lithium sulfide
e Lithium nitrate
f Lithium oxide
g Lithium hydroxide

7 ▶ D

8 ▶ a It is a metal because it forms a positive ion. Metals form positive ions but non-metals form negative ions.

b Excelium chloride $ExCl_3$; excelium sulfate $Ex_2(SO_4)_3$

8 ▶ Sodium chloride has a giant lattice structure of alternating positive and negative ions. It has a high melting point because it takes a lot of energy to overcome the strong electrostatic forces of attraction between oppositely charged ions.

CHAPTER 7

1 ▶

a	MgO	ionic
b	CH_3Br	covalent
c	H_2O_2	covalent
d	$FeCl_2$	ionic
e	NaF	ionic
f	HCN	covalent

2 ▶ Each line represents a covalent bond, a shared pair of electrons.

3 ▶ When carbon dioxide sublimes, only intermolecular forces of attraction are broken. Intermolecular forces of attraction are weak and require little energy to break.

When silicon dioxide melts all the covalent bonds in the giant structure must be broken. Covalent bonds are strong so this requires a lot of energy.

4 ▶ Simple molecular, because it is a liquid at room temperature. Only weak intermolecular forces of attraction must be broken to melt solid hexane. Compounds with giant structures have high melting points and boiling points and will be solids at room temperature.

5 ▶ a No covalent bonds are broken (so it makes no difference that there is a double bond between oxygen atoms but only a single bond between hydrogen atoms). Only intermolecular forces of attraction are broken, so the *intermolecular forces of attraction* must be stronger in oxygen.

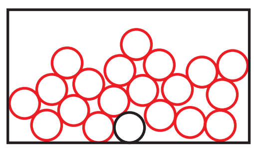
b Electrostatic forces of attraction between oppositely charged ions in NaCl are stronger than intermolecular forces of attraction in CCl_4. No covalent bonds are broken so the strength of ionic and covalent bonds cannot be compared from this information.

6 ▶ False. No covalent bonds are broken, so it is not possible to deduce any information about the strength of covalent bonds. Only intermolecular forces of attraction are broken. The intermolecular forces of attraction must be stronger in iodine.

7 ▶ A

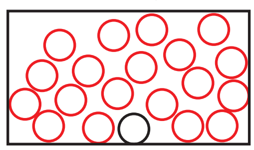
UNIT 1 EXAM PRACTICE

1 ▶ a C (1)

b 

Particles randomly arranged (1) and mostly touching each other (1)

The diagram below would only score 1 mark – for the random arrangement



c Number of protons: 1 (1)
Number of neutrons: 2 (1)
Number of electrons: 1 (1)

d $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

(3: 1 mark for all formulae correct; 1 mark for balancing; 1 mark for state symbols)

e A —NH_4SO_4 is incorrect (1) (because the ammonium ion is NH_4^{+} and the sulfate ion is SO_4^{2-})

f D (1)

2 ▶ a Atomic number (1); groups (1); chemical properties (1)

b H (1) and Ar (1)

3 ▶ a A and D (1)

b i C (1)

ii 3– (1)

c Atomic number: 7 (1)

Mass number: 13 (1)

d Nitrogen/N (1)

4 ▶ a i 2+ (1)

ii Loses 2 electrons: *1 mark for loses electrons; 1 mark for correct number of electrons*

iii $SrBr_2$ (1)

iv High melting point (1)

Strong electrostatic forces of attraction between oppositely charged ions (1)

Require a lot of energy to break (1)

b The relative atomic mass of an element is the weighted average mass of the isotopes of the element (1).

It is measured on a scale on which a carbon-12 atom has a mass of exactly 12 (1).

c $\frac{50.69 \times 79 + 49.31 \times 81}{100}$ (1)

79.99 (1)

5 ▶ a 720 (1)

b Covalent bonding (1); shared pair of electrons (1).

c Diamond has higher melting point (1); C_{60} fullerene intermolecular forces of attraction broken but covalent bonds broken when diamond melts (1); covalent bonds stronger than intermolecular forces of attraction (1); more energy required to break stronger forces (1).

d $C(s) + O_2(l) \rightarrow CO_2(g)$

1 mark for state symbol of O_2

1 mark for formula and state symbol of carbon dioxide

e i MgO (1)

ii $2Mg + CO_2 \rightarrow 2MgO + C$

1 mark for formulae of reactants

1 mark for formulae of products

1 mark for balancing

6 ▶ a Dissolving (1); diffusion (1)

b It will be smaller/have disappeared (1)

c A blue solution/uniform blue colour throughout the beaker (1)

d i Measuring cylinder/burette/pipette (1)

ii Lighter in colour (1)

e Heat the solution to boil off some water (1); allow the solution to cool and crystallise (1); filter off the crystals (1); *1 mark max for just stating: 'crystallisation'*

f C (1)

g $CuSO_4{\bullet}5H_2O(s) \rightarrow CuSO_4(s) + 5H_2O(g)$

All 3 state symbols needed for the mark

7 ▶
- Draw a pencil line across a piece of chromatography/filter paper about 1 cm from the bottom of the paper/near the bottom of the paper *(pencil essential)* (1).
- Put a spot of the purple liquid on the pencil line (1).
- Suspend the chromatography paper in a beaker/container that contains a small amount of solvent/named solvent (1).
- Bottom of paper in solvent/solvent is below the pencil line (1).
- Allow the solvent to move up the paper/leave for some time/leave until the solvent is near the top of the paper (1).
- Count the number of spots/the number of spots is equal to the number of dyes (1).

If no other marks scored then 1 mark awarded for stating '(paper) chromatography'.

8 ▶
- Lithium is a metal so will have ionic bonding in its compounds (1).
- Boron and sulfur are non-metals so will have covalent bonding in their compounds (1).

Accept: student is correct about lithium nitride and tetrasulfur teranitride but incorrect about boron nitride for 2 marks

- Lithium nitride has a high melting point due to having a giant ionic structure (1).
- Strong electrostatic forces of attraction between oppositely charged ions require a lot of energy to break (1).
- Boron nitride has a very high melting point so has a giant (covalent) structure (1).
- Large amount of energy is required to break the strong covalent bonds throughout the giant structure (1).
- S_4N_4 has a simple molecular / covalent molecular structure (1).
- Not much energy required to break weak intermolecular forces of attraction (1).

UNIT 2 ANSWERS

CHAPTER 8

1 ▶ They all react in the same way/have the same/similar chemical properties.

2 ▶ a Na^+

b i Lithium hydroxide LiOH

ii Sodium hydroxide NaOH

iii Rubidium hydroxide RbOH

iv Sodium oxide Na_2O

v Potassium oxide K_2O

vi Caesium oxide Cs_2O

3 ▶ C

4 ▶ a The sodium floats; the sodium melts into a ball; there is fizzing; the sodium moves around on the surface of the water; the piece of sodium gets smaller and eventually disappears.

b Lithium is less reactive than sodium so fizzes less rapidly/moves around more slowly/takes longer to disappear. Does not melt into a ball – Li has a higher melting point and heat is not given out as quickly as the reaction is less vigorous.

c sodium + water → sodium hydroxide + hydrogen

d $2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$

5 ▶ a A = lithium
b B = potassium; C = hydrogen; D = potassium hydroxide
c $2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$
d The paper would turn blue /purple.
e Lots of heat is evolved. The melting point of potassium is low.
f E = sodium and F = sodium oxide
sodium + oxygen → sodium oxide
$4Na(s) + O_2(g) \rightarrow 2Na_2O(s)$

6 ▶ D

7 ▶ a False
b True
c False: lithium does react with chlorine to form lithium chloride but the formula of lithium chloride is LiCl.

8 ▶ a Lower melting point than francium because melting point decreases down the group.
b Edexcelium hydroxide and hydrogen
c More reactive than francium, as reactivity increases down the group.
d $2Ed + 2H_2O \rightarrow 2EdOH + H_2$
e Alkaline (because OH^- ions are formed).
f Ed_2O

CHAPTER 9

1 ▶ They have similar chemical properties/react in the same way.

2 ▶ C

3 ▶ a Any temperature above 60 °C and less than 250 °C – actual value is 184 °C.
b There is not a temperature because the melting point of bromine is above the boiling point of chlorine.

4 ▶ a i Grey
ii Purple
b $I_2(g)$
c $I_2(s) \rightarrow I_2(g)$
d I^-
e KI

5 ▶ a Ts_2
b Solid because the melting point increases down Group 7 and iodine, which is above tennessine, is a solid at room temperature.
c Higher because melting point increases down Group 7.
d Darker, because the colour gets darker down Group 7.
e i $Cl_2(g) + H_2(g) \rightarrow 2HCl(g)$
ii $Ts_2 + H_2 \rightarrow 2HTs$
f i KBr
ii Potassium tennesside, KTs

CHAPTER 10

1 ▶ a 78.1% b 21.0% c 0.04% d 0.9%

2 ▶ a 95 – 80 = 15 cm³ of oxygen
$\frac{15}{95} \times 100 = 15.8\%$
b The answer is less than expected. The apparatus was not left for long enough; there was not enough time for all the oxygen in the air to react. The experiment could be improved by leaving the apparatus set up for longer.

3 ▶ B

4 ▶ a i MgO
ii CO_2
iii SO_2
b i $2Mg + O_2 \rightarrow 2MgO$
ii $S + O_2 \rightarrow SO_2$
iii $SO_2 + H_2O \rightarrow H_2SO_3$
c Sulfurous acid

5 ▶ a

	Left-hand syringe volume of gas / cm³	Right-hand syringe volume of gas / cm³
start of experiment	68	52
end of experiment	48	46

b Start: 130 cm³ End: 104 cm³ *including 10 cm³ for the connecting tube*
c Volume of oxygen = 26 cm³;
percentage oxygen = 26/130 × 100 = 20%
d i The copper was not in excess — there was no unreacted copper left at the end. — L
ii Some gas escaped from the apparatus as the student moved the plungers of the gas syringes in and out. — H
iii The student did not allow the apparatus to cool down before taking the final readings on the gas syringe. — L
iv The student did not wait until there was no further change in the total volume of gas. — L
v Some magnesium powder was mixed with the copper. *(Heated magnesium reacts with oxygen and nitrogen.)* — H

6 ▶ Carbon dioxide is one of the gases responsible for the greenhouse effect. These gases absorb IR (infrared) radiation that has been emitted from the Earth's surface. They then re-radiate it in all directions, warming the atmosphere. Heating of the atmosphere could lead to climate change.

7 ▶ C

CHAPTER 11

1 ▶ a Sodium, magnesium, iron, copper
b $2Na + 2H_2O \rightarrow 2NaOH + H_2$
c $Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g)$
d Hydrogen
e magnesium + hydrochloric acid → magnesium chloride + hydrogen
f $Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$

2 ▶ a The results suggest that D is the least reactive as it does not react at all with sulfuric acid whereas the other metals do react.
However, D could be a metal like aluminium that has a protective oxide layer and so the student's conclusion is not certain.

b They should record how rapidly/vigorously each one fizzes/the number of bubbles per second/ how quickly the metal disappears.

c $X(s) + H_2SO_4(aq) \rightarrow XSO_4(aq) + H_2(g)$

3 ▶ a Hydrogen

b Aluminium chloride solution

c $2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)$

d Aluminium is covered by a very thin, but very strong, layer of aluminium oxide which prevents the acid getting at the aluminium underneath. On heating, the acid reacts with the oxide and removes it. The aluminium then shows its true reactivity, and produces a vigorous reaction.

4 ▶ Drop a very small piece into cold water. If it reacts, judge its reactivity relative to K, Na, Ca or Mg.

If it does not react, add a small piece to dilute hydrochloric acid and warm if necessary. Rapid reaction in the cold acid would place it as 'similar to magnesium'. A few bubbles of hydrogen in the cold acid, and more on heating would place it as 'similar to iron or zinc'.

If there is no reaction, then it is 'below hydrogen'.

5 ▶ a The iron/steel must be exposed to oxygen (air) and water.

b Painting prevents oxygen and water from coming into contact with the iron/steel.

c It is iron/steel coated with zinc.

d i The steel rusts. The steel is now exposed to air and water.

ii The steel does not rust. The zinc is more reactive than iron (steel) and reacts with the air and water more readily than the iron does.

6 ▶ D

CHAPTER 12

1 ▶ a Blue

b Red

2 ▶

Solution	pH	Strongly acidic	Weakly acidic	Neutral	Weakly alkaline	Strongly alkaline
potassium iodide	7			✓		
propanoic acid	4.2		✓			
sodium carbonate	9.5				✓	
potassium hydroxide	13					✓
iron(III) chloride	2.4	✓				
nitric acid	1.3	✓				

3 ▶ a Sodium chloride

b Potassium nitrate

c Ammonium sulfate

4 ▶ a KBr

b $RbNO_3$

c $CaSO_4$

d NH_4NO_3

5 ▶ H^+

6 ▶ Produces hydroxide ions in solution
$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$

7 ▶ a i $2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

ii $NaOH + HNO_3 \rightarrow NaNO_3 + H_2O$

iii $NH_3 + HCl \rightarrow NH_4Cl$

b Neutralisation

8 ▶ a Potassium hydroxide and nitric acid

b Barium hydroxide and sulfuric acid

c Calcium hydroxide and hydrochloric acid

9 ▶ Red litmus goes blue; solution is alkaline because OH^- ions are present.

10 ▶ B

CHAPTER 13

1 ▶ a Chlorine **b** Ammonia **c** Carbon dioxide

d Hydrogen **e** Oxygen

2 ▶ a A clean platinum or nichrome wire is dipped into concentrated hydrochloric acid and then into the white powder so that some sticks on the end. The wire and the powder are then held just within a non-luminous (roaring) Bunsen burner flame and the colour observed. Calcium ions give an orange-red flame colour.

b Add dilute hydrochloric acid or dilute nitric acid and look for fizzing. Bubble the gas produced through limewater. If the limewater turns milky (white precipitate) then carbon dioxide was produced in the reaction and carbonate ions were originally present.

3 ▶ a K^+ **b** Li^+ **c** Cu^{2+} **d** Ca^{2+} **e** Na^+

4 ▶ a G = potassium carbonate; H = potassium chloride; I = carbon dioxide

b $K_2CO_3 + 2HCl \rightarrow 2KCl + CO_2 + H_2O$

5 ▶ a Add water to the mixture and stir. Filter the mixture to remove the green solid. Heat the solution (filtrate) to evaporate off the water and leave crystals of potassium nitrate.

b Carry out a flame test on the solid. If it is a copper salt, the flame will have a blue–green colour. Add some dilute hydrochloric acid to a small amount of the solid in a test tube. If the solid is a carbonate, there should be fizzing and the gas produced should turn limewater milky/cloudy/white precipitate.

6 ▶ a Add a few drops of the liquid to some anhydrous copper(II) sulfate. If the colour changes from white to blue then water is present.

b anhydrous copper(II) sulfate + water → hydrated copper(II) sulfate

c $CuSO_4(s) + 5H_2O(l) \rightarrow CuSO_4{\cdot}5H_2O(s)$

d Test with universal indicator solution.
Result with hydrochloric acid: solution goes red.
Result with sodium carbonate solution: solution goes blue (the solution is slightly alkaline).

Test with blue litmus paper.

Result with hydrochloric acid: litmus paper goes red.
Result with sodium carbonate solution: litmus paper remains blue.

Test by adding a carbonate, e.g. calcium carbonate to each solution.
Result with hydrochloric acid: fizzing, a gas is produced that turns limewater milky.
Result with sodium carbonate solution: no reaction.

Test by adding dilute hydrochloric acid to each solution.
Result with hydrochloric acid: no reaction.
Result with sodium carbonate solution: fizzing, a gas is produced that turns limewater milky.

A flame test could be tried – flame tests using the method described in this chapter do not work terribly well on solutions – it would be better to evaporate off the water to produce a solid (if the solution is sodium carbonate) and then test that. Alternatively the solution could be sprayed into the flame (care!).
Result with hydrochloric acid: no flame colour.
Result with sodium carbonate solution: yellow flame.

Note: if the solution is evaporated to dryness there will be a solid residue with sodium carbonate solution but not with dilute hydrochloric acid – but this is not a chemical test, it just involves a physical process.

UNIT 2 EXAM PRACTICE

1 ▶ D (1)

2 ▶ A (1)

3 ▶ B (1)

4 ▶ a Potassium oxide (1)

b The piece of lithium floats (1); hydrogen gas is formed (1)

c i Name: hydroxide (1); formula: OH^- (1)

ii Dip universal indicator paper into the solution or put a spot of the solution on to the universal indicator paper and observe colour (1); compare colour to a colour chart (1)

iii Any value from 10–14 (alkaline) (1)

iv $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

(1) *for all formulae correct and on correct sides*

(1) *for balancing*

(1) *for state symbols*

v Neutralisation (1)

d i It forms a 1+ ion in compounds (1); it reacts with water and air (1)

ii The density increases from lithium to sodium but decreases from sodium to potassium (1).

The trend is not clear for the whole group (1).

e i Dip a clean piece of (nichrome/platinum) wire into concentrated hydrochloric acid (1); and then into the lithium chloride (1); hold the wire just within a non-luminous (roaring) Bunsen burner flame and observe the colour (1).

ii Lithium chloride will have a red flame (due to Li^+ ion) (1); sodium chloride will have a yellow flame (due to Na^+ ion) (1).

5 ▶ a Wear eye protection (1)

b Too dangerous to carry out (1); the reaction with water is already violent and the reaction with hydrochloric acid will be more violent (1).

c Most reactive to least reactive: Rosium; Amelium; Mollium; Pearsonium (1)

d Hydrogen (1)

e $MI + 2HCl \rightarrow MICl_2 + H_2$

(1) for all reactants and products correct

(1) for balancing

6 ▶ a Halogens (1)

b i Lighter in colour than chlorine (1)

ii Lower boiling point than chlorine (1)

c i 5 (1)

ii Test: put a piece of damp (blue) litmus paper/ universal indicator paper into a test tube of gas (1).

Positive result: paper turns white/bleached (1).

Accept blue litmus paper/universal indicator paper will turn red then white

d i Hydrogen fluoride (1); HF (1)

ii H^+ (1)

iii The anhydrous copper(II) sulfate changes colour from white (1); to blue (1); because dilute hydrochloric acid contains water (1).

7 ▶ a Nitrogen (1)

b i The oxygen in the air is used up as it reacts with the iron (1).

Water is pushed in by the atmosphere to take its place / the pressure in the measuring cylinder is reduced (1).

ii All the oxygen has reacted and so there is nothing to react with the iron (1).

iii Hydrated iron(III) oxide (1)

iv There is no oxygen present (1); oxygen is required for the splint to burn (1).

v The total amount of oxygen present in the original sample of air is $94 - 75 = 19\,cm^3$ of oxygen (1).

$9\,cm^3$ of oxygen is used up after one day, therefore there is $19 - 9 = 10\,cm^3$ of oxygen still present after one day (1).

This is in a total volume of $85\,cm^3$ (1) (reading on the measuring cylinder after 1 day).

Percentage oxygen $= \frac{10}{85} \times 100 = 11.8\%$ (1)

vi These will produce hydrogen when they react with the water present (1).

Hydrogen gas will take up space in the measuring cylinder, so the volume change will not show the volume of oxygen used up (1).

vii Use more iron filings / more finely divided (higher surface area) iron filings / warm the apparatus (1).

c **i** Blue (1)
ii $S + O_2 \rightarrow SO_2$ (1)
iii The litmus solution will be red (1).

8 ▶ **a** Flame test (1); orange-red flame indicates calcium/Ca^{2+} ions (1).
Add hydrochloric acid/nitric acid to the limestone (1); fizzing observed (1); gas produced turns limewater cloudy/milky/white precipitate which indicates carbonate/CO_3^{2-} ions (1).
b **i** $CaCO_3$ (1)
ii Ca^{2+} (1) and O^{2-} (1)
iii $CaCO_3 \rightarrow CaO + CO_2$ (1)
c Blue colour (1); hydroxide ions are present (1); hydroxide ions make the solution alkaline (1).
d Carbon dioxide produced (1); CO_2 can cause climate change/global warming (1).

9 ▶ Dissolve all the substances in water (1).
Test with litmus solution/paper or universal indicator solution/paper (1).
Citric acid is the only one where the litmus/universal indicator goes red (1).
Potassium chloride: no effect on litmus, universal indicator goes green (1).
Litmus goes blue/universal indicator goes blue/purple for sodium hydroxide and potassium hydroxide (1).
Distinguish between sodium hydroxide and potassium hydroxide using a flame test (1).
Yellow flame for sodium hydroxide and lilac flame for potassium hydroxide (1).

UNIT 3 ANSWERS

CHAPTER 14

1 ▶ C

2 ▶ B

3 ▶ **a** chemical, heat, less, increases/goes up
b heat, chemical, more, decreases/goes down
c exothermic
d temperature, one, degree, Celsius

4 ▶ **a** 5.93 kJ;
b 9.87 kJ;
c 0.294 kJ or 0.365 kJ if 6 g is taken into account for the mass of the final solution

5 ▶ Correctly balanced equations for any two exothermic reactions e.g. any combustion reactions (metals, hydrogen, hydrocarbons, etc. in oxygen), neutralisation reactions involving alkalis and acids, or magnesium and acids.
For example, $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ or $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

6 ▶ **a** Exothermic **b** Exothermic **c** Endothermic
d Exothermic **e** Exothermic

7 ▶ The cans have two chambers. The outer chamber contains the beverage or food to be heated. The inner chamber contains calcium oxide and water. The calcium oxide and water are kept separate by a seal. Pushing a button on the bottom of the can breaks the seal and allows the calcium oxide and water to come into contact. The following exothermic reaction takes place:
$CaO + H_2O \rightarrow Ca(OH)_2$

8 ▶ **a** Her first two results were not reliable. There was too much difference between them.
b Any two from: wear a lab coat; avoid touching the hot copper can; tie long hair back.
c Heat energy change = $Q = mc\Delta T$
Mass of water being heated = m = 100 g
c is the specific heat capacity of the water
c = 4.18 J/g/°C
Temperature change of water = ΔT = 55.0 − 19.0 = 36.0 °C
Heat evolved = $Q = mc\Delta T$ = 100 × 4.18 × 36.0 J = 15 048 J = 15.0 kJ to 3 significant figures
d Mass of hexane burned = 35.62 − 35.23 g = 0.39 g
Heat evolved per gram = $\frac{15.048}{0.39}$ = 38.6 kJ/g to 3 significant figures
e Any two from: misreading one of the weighings of the spirit burner so that it looked as if less hexane had been burned than was really the case; misreading the thermometer to give a final temperature higher than it should have been; adding less than 100 cm^3 of water to the flask, so that the temperature went up more than it should because the heat was going into a smaller volume of water.
f Any two from: heat loss to the surroundings; heat is lost to warm up the copper calorimeter or the thermometer; incomplete combustion of the fuel.

9 ▶ **a** Heat energy change = $Q = mc\Delta T$
Mass of solution being heated = m = 50 g (the mass of the lithium chloride is relatively small and it is ignored in the calculation)
c is the specific heat capacity of the diluted solution of lithium chloride, which we assume to be the same as the heat capacity of water: c = 4.18 J/g/°C
Temperature change of water = ΔT = 33.5 − 17.0 = 16.5 °C
Heat evolved = $Q = mc\Delta T$ = 50 × 4.18 × 16.5 J = 3448.5 J = 3.45 kJ to 3 significant figures

b Heat energy change per gram

$$= \frac{\text{heat energy change } (Q)}{\text{mass of lithium chloride dissolved}}$$

$$= \frac{3.45}{5.15} = 0.670 \text{ kJ/g to 3 significant figures}$$

c Any two from: heat loss to the surroundings; heat is lost to warm up the solution container or the thermometer; incomplete transfer of the salt from the weighing boat into the water; some salt does not dissolve completely in water.

CHAPTER 15

1 ▶ a 2.13 cm^3/s

b 0.175 g/min

c 0.0103 g/s or 0.616 g/min

2 ▶ a concentration/amount, reactants, products

b i increases, increases

ii increases, directly, proportional

iii kinetic, increases

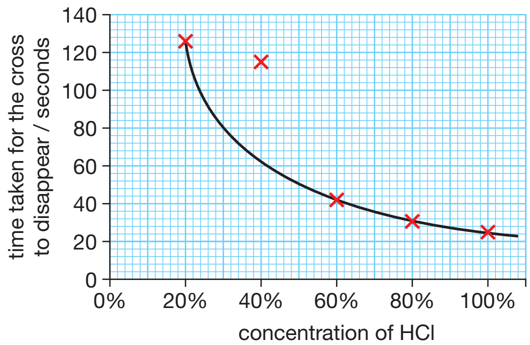
iv increases, unchanged

3 ▶ a The sulfur produced is a solid.

b i So the concentration of sodium thiosulfate/the other reactant remains constant.

ii 10 and 30

iii

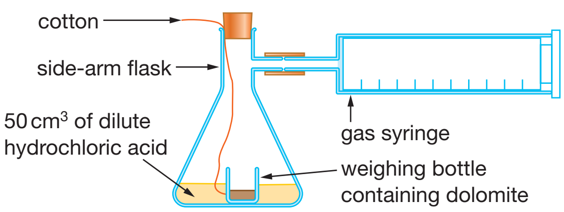


iv Circle the point at 40% acid concentration

v C

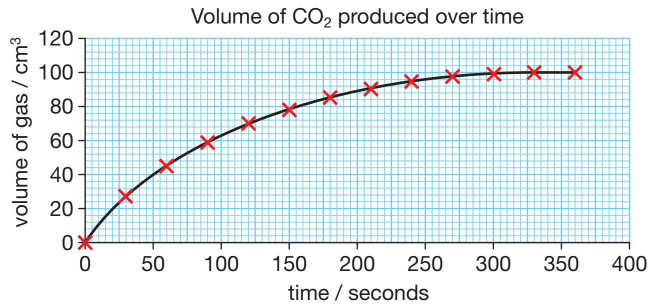
vi 7.94×10^{-3} sec^{-1}

4 ▶ a



Collection of gas over water into an inverted measuring cylinder is an acceptable alternative. Pieces of dolomite in a weighing bottle are put into the conical flask before the reaction starts. This is to make sure that the reaction can be started without losing any carbon dioxide.

b Graph should be completely smooth with the axes properly labelled.



c At the very beginning of the reaction. The concentrations of the reactants are the highest at the beginning of the reaction.

d 70 seconds (read this off the graph; allow some tolerance depending on the size of graph paper available)

e Volume produced within the first 80 seconds = 55 cm

(The average rate = $\frac{55}{80}$ = 0.688 cm^3/s to 3 significant figures)

f i There would be a lower initial rate; same volume of gas.

ii There would be a lower initial rate; half the volume of gas (50 cm^3).

iii The initial rate would be the same; half the volume of gas (50 cm^3). (The initial rate depends on the original concentration of the acid, which is the same.)

iv The initial rate would be faster; same volume of gas.

5 ▶ a Independent variable – the solid used to catalyse the reaction; dependent variable – the time taken for 50 cm^3 of oxygen to be collected

b Any four from: amount/mass of the solid; surface area/size of the solid; volume of the H_2O_2 solution used; concentration of the H_2O_2 solution used; amount of the oxygen gas to be collected; rate of stirring; temperature of the reaction mixture.

c E B C D A F (E and B can be the other way round)

d Manganese(IV) oxide

UNIT 3 EXAM PRACTICE

1 ▶ D

2 ▶ a Endothermic (1)

b Exothermic (1)

c Endothermic (1)

d Exothermic (1)

e Exothermic (1)

f Endothermic (1)

g Exothermic (1)

3 ▶ a i 19.3 (1), 16.6 (1), 2.7 (1)

ii C (1)

b i $Q = mc\Delta T = 100.0 \times 4.2 \times (23.2 - 15.9) = 3.066$ kJ

calculation of temperature change (1)

correct answer for Q (1)

ii $\frac{3.066}{5}$ (1) = 0.613 kJ/g to 3 significant figures (1)

c Heat loss to the surrounding air through beaker (1)

Some magnesium chloride was left on the weighing boat / did not dissolve in water completely (1)

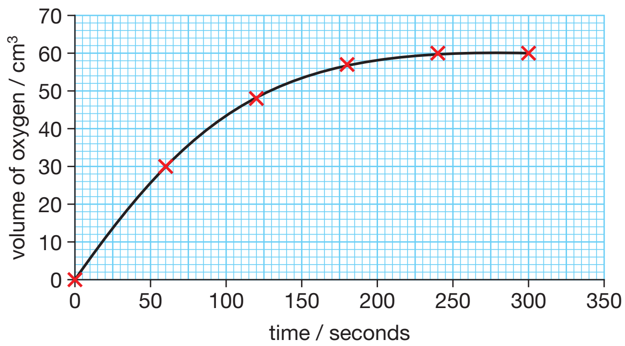
4 ▶ a $2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$

correct formulae of reactants and products (1)

correct balancing (1)

b To prevent the loss of oxygen at the beginning of the reaction (1)

c



correct labelling of axes with units (1)

correct points plotted (2)

a smooth curve of best fit, going through all of the points (1)

d i 125 seconds (1)

ii $43\,cm^3$ (1)

iii $\frac{53}{150} = 0.353\,cm^3/sec$

correct numerical answer (1)

correct unit (1)

iv $0.26–0.33\,cm^3/s$

Drawing a tangent at t = 90 s (1)
Correct calculation of gradient (1)
Correct answer for rate (1)

e The reaction has stopped (1) because all the hydrogen peroxide has been used up (1).

f Weigh a sample of manganese(IV) oxide and add to hydrogen peroxide (1). Oxygen is produced at a faster rate with manganese(IV) oxide than without (1). Filter the reaction mixture and dry the solid (1). Re-weigh the solid and the mass should be the same as before if it acts as a catalyst (1).

g Shallower curve than the original (1) but the end volume remains the same (1)

h Shallower curve than the original (1) and only $30\,cm^3$ (half the volume) of gas is produced (1)

5 ▶ a Record the initial temperature of the copper(II) sulfate solution, before Zn was added (1);
Stir the reaction mixture immediately after Zn was added (1).

b Students should draw diagram similar to Figure 14.8 with labels for thermometer (1) and polystyrene cup (1). (The glass beaker can be omitted.)

c *m* should be the mass of the solution, so the student should have used 50 instead of 3.40 (1). ΔT is the temperature change rather than the maximum temperature, so 31.4 rather than 49.6 (1). To convert J to kJ, the value of *Q* should be divided by 1000 (1).
Correct answer: 6.594 kJ (1)

d The calculated value is less exothermic (or lower in value) than the theoretical value (1), meaning less heat energy was released or less temperature rise was measured (1).

The reasons could be: Any two from:

- Heat loss to the surroundings (1)
- Incomplete reaction (1)
- Some copper(II) sulfate solution was left in the measuring cylinder (1).

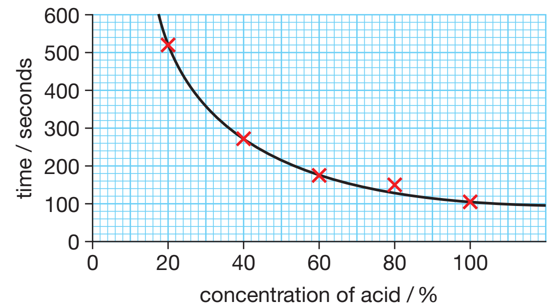
e 62.8 °C (1)

6 ▶ a The mass (1) and the surface area / size (1)

b To let the gas escape but keep the liquid inside the conical flask (1)

c i B (1)

ii



correct labelling of axes with units (1)

correct points plotted (2)

a smooth curve of best fit, going through all but one point (1)

iii 150 seconds (1)

iv C (1)

d The mass of CO_2 given off is directly (1) proportional (1) to the concentration of the acid.

e A

7 ▶ a $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$
Balancing the equation (1)
State symbols correct (2)

b Any number between 46 – $50\,cm^3$ (1)

c $2.2—2.3\,cm^3/sec$ (2)

d Drawing a tangent at the origin (1). Drawing a triangle for calculating the gradient of the tangent (1). Gradient calculated in the range of 2.4 to $3.5\,cm^3/sec$ (1).

e The rate decreases and becomes zero eventually (1). This is because the concentration of the reactants decreases over time (1).

f The student read the volume before 40 seconds (1).

g H_2 has very low density so the mass change would be too small to be measured precisely/accurately (1).

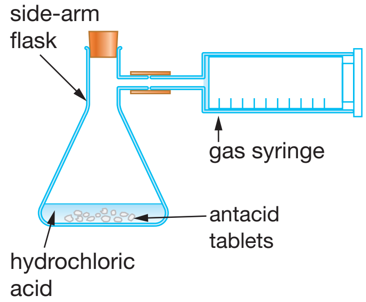
h Curve ii: Half the mass of the Mg powder was used (1)

Curve iii: Higher temperature of the reaction mixture/ higher concentration of the HCl acid (1)

8 ▶ Take a number of antacid tablets, crush half of the tablets into powder using a pestle and mortar (1).

Set up two conical flasks, each containing $50\,cm^3$ of the dilute hydrochloric acid measured with a $50\,cm^3$ measuring cylinder (1).

Prepare the apparatus as shown in the diagram, clamp the gas syringe in position with the clamps, bosses and stands. *(2 for the diagram, –1 mark for each mistake made)*



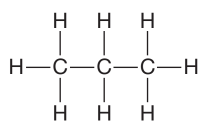
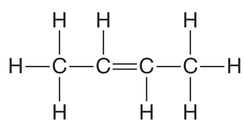
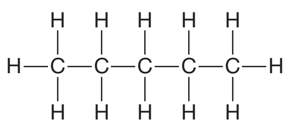
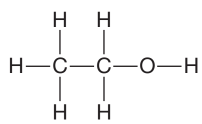
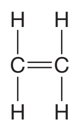
Add the antacid tablets either in whole or as powder into the conical flask and place a bung on top of the conical flask (1).

Time how long it takes to produce a certain volume (for example, 20 cm^3) of gas or measure how much gas is produced in a certain amount of time (for example, 30 seconds) *(2 marks, 1 for time and 1 for volume)*. Compare the results to see the effect of surface area.

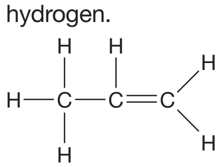
UNIT 4 ANSWERS

CHAPTER 16

1 ▶

Molecular formula	Displayed formula	Structural formula	General formula
C_3H_8		$CH_3CH_2CH_3$	C_nH_{2n+2}
C_4H_8		$CH_3CH{=}CHCH_3$	C_nH_{2n}
C_5H_{12}		$CH_3CH_2CH_2CH_2CH_3$	C_nH_{2n+2}
C_2H_6O		CH_3CH_2OH	$C_nH_{2n+2}O$
C_2H_4		$CH_2{=}\ CH_2$	C_nH_{2n}

2 ▶ a C: it contains an element other than carbon and hydrogen.

b 

c C_nH_{2n+2}

CHAPTER 17

1 ▶ C

2 ▶ B

3 ▶ a hydrogen, carbon

b fossil fuel, mixture, fractions, fractional, boiling/condensation points, refinery gases, gasoline, kerosene, diesel, oil, fuel, oil, bitumen, darker, increases, increases

c heat, energy

d oxygen, water, sulfuric, acid, rain

e carbon monoxide, oxygen

4 ▶ a Carbon and hydrogen

b The different fractions have different boiling/condensation points.

c Gasoline – petrol for cars; diesel – fuel for lorries or buses

d Any two from: refinery gas, kerosene, fuel oil or bitumen.

e The average size of the molecules in gasoline is smaller than in diesel. Diesel is darker in colour and more viscous than gasoline.

f Any between n = 5–10 for C_nH_{2n+2}

g i $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

ii Carbon monoxide is poisonous as it reduces the blood's ability to carry oxygen around the body.

5 ▶ a The sulfur (or sulfur compound) burns to make sulfur dioxide. The sulfur dioxide reacts with water and oxygen in the atmosphere to produce sulfuric acid that falls as acid rain.

b The spark in the engine causes nitrogen to react with oxygen to produce various oxides of nitrogen.

c Sulfur dioxide reacts with water and oxygen in the atmosphere to produce sulfuric acid. The sulfuric acid in acid rain can react with calcium carbonate and corrode the buildings.

6 ▶ a i Dodecane has a darker colour than pentane.

ii Dodecane is more viscous than pentane.

iii Dodecane has a higher boiling point than pentane.

b Fractional distillation

CHAPTER 18

1 ▶ A

2 ▶ a Saturated hydrocarbons contain only C–C single bonds and have no double or triple bonds.

b i $C_{11}H_{24}$

ii Liquid

iii $C_{11}H_{24}(l) + 17O_2(g) \rightarrow 11CO_2(g) + 12H_2O(l)$

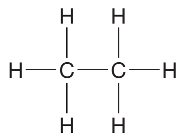
iv $2C_{11}H_{24} + 23O_2 \rightarrow 22CO + 24H_2O$

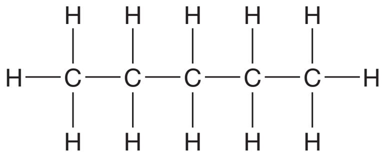
Carbon monoxide is poisonous, as it reduces the ability of the blood to carry oxygen around the body.

3 ▶ a i Methane

ii Propane

iii Pentane

b i  CH_3CH_3

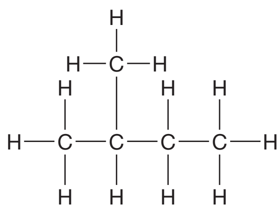
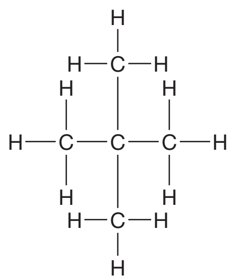
ii  $CH_3CH_2CH_2CH_2CH_3$

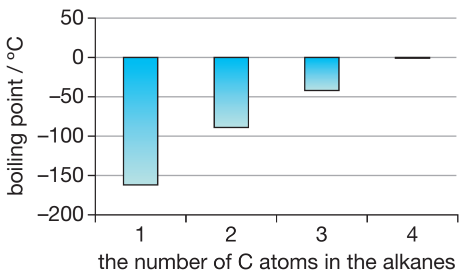
4 ▶ a i C_5H_{12}

ii C_4H_{10}

iii C_5H_{12}

b Butane

5 ▶  and 

6 ▶ a 

b Any number in range 25–45 °C

c As molecules become larger, the intermolecular forces become stronger and take more energy to break. So the boiling points increase.

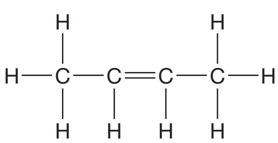
CHAPTER 19

1 ▶ C

2 ▶ a i Propene

ii Ethene

iii But-1-ene

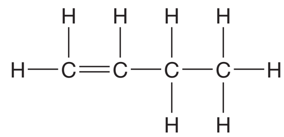
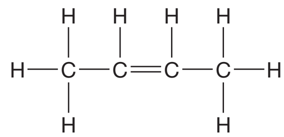
b  $CH_3CH{=}CHCH_3$

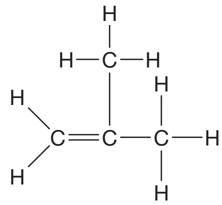
3 ▶ a i Any two from: same general formula; same functional group or similar chemical properties; show a gradation in physical properties; each member differs from the next by a $–CH_2–$.

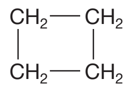
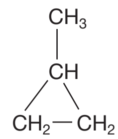
ii Unsaturated compounds contain one or more carbon–carbon double or triple bonds.

b i Starting: orange; Finishing: colourless

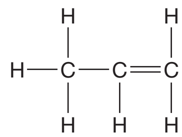
ii Orange

c  



d  

4 ▶ a A carbon–carbon double bond or an alkene

b 

5 ▶ a A, B, C and E

b C

c i $CH_3CH_2CH_2CH_3$

ii Butane has only C–C single bond/no C=C double bond/is saturated; the formula C_4H_{10} fits the general formula C_nH_{2n+2} for an alkane

CHAPTER 20

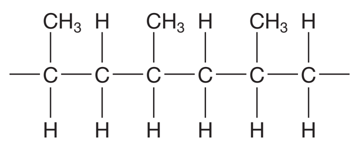
1 ▶ a Unsaturated: containing one or more carbon–carbon double or triple bonds.

Hydrocarbon: compound containing carbon and hydrogen only

b $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

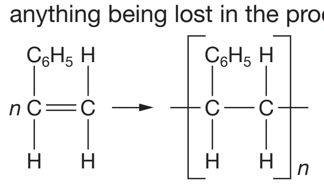
c Ethene can be used to make addition polymer polyethene, which is used for making plastic bags, milk bottles etc.

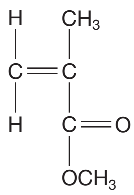
2 ▶ a Joining up lots of little molecules (monomers) to make one big molecule (a polymer).

b 

The 'continuation' bonds at each end are an important part of this structure. Marks will be lost in an exam if they are omitted.

c Joining two or more molecules together without anything being lost in the process.

d 

e 

UNIT 4 EXAM PRACTICE

1 ▶ a D (1)

b Used as liquefied petroleum gas / domestic heating or cooking (1)

c Gasoline (1)

d As the number of carbon atoms increases, the boiling point of a hydrocarbon increases (1).

This is because the intermolecular forces increase as the number of carbon atoms increases (1), so it takes more energy to break them during boiling. (1)

e $2C_{15}H_{32} + 31O_2 \rightarrow 30CO + 32H_2O$

correct formulae of products (1)

correct balancing of the equation (1)

f CO reduces the capacity of blood to transport oxygen around the body (1).

2 ▶ a E contains an element that is not carbon or hydrogen. (1)

b Propane (1)

c A and C (1)

d i B and D (1)

ii C_nH_{2n+2} (1)

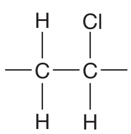
iii Any two for 2 marks from:

Same functional group / same or similar chemical properties (1)

Show a trend in physical properties (1)

Each member differs from the next by a $-CH_2-$ unit (1)

e i Molecules which can join up to form a polymer (1)

ii  (1)

iii *Either:* burying in landfill sites is a better method because (any two advantages for 2 marks from:) there is no emission of poisonous carbon monoxide (1); no carbon dioxide to contribute to global warming (1); and no sulfur dioxide to contribute to acid rain (1).
Disadvantages of landfill: using up space for landfill sites (1); no energy is generated to provide heat (1).

Or: incineration is a better method because no space is filled up in landfills (1); and energy can be generated to provide heat for office buildings (1).

Disadvantages of incineration: (any two for 2 marks from:) emission of poisonous carbon monoxide (1); carbon dioxide is produced which contributes to global warming (1); or sulfur dioxide is produced which contributes to acid rain (1).

3 ▶ a Starting colour: white (1); finishing colour: blue (1)

b To condense the steam/water vapour back to water (1)

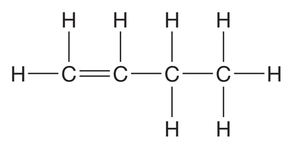
c Limewater (1); colourless solution (1), turns cloudy/ forms white precipitate (1)

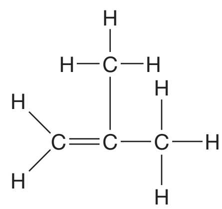
d $C_{21}H_{44} + 32O_2 \rightarrow 21CO_2 + 22H_2O$ (3, *1 mark for the correct formula of oxygen, 1 mark for the correct formulae of the products, 1 for balancing*)

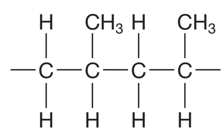
4 ▶ a Test: Add bromine water (1)

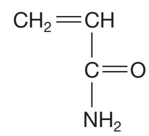
Result with compound 1: Solution changes colour from orange to colourless (1)

Result with compound 2: Solution stays orange (1)

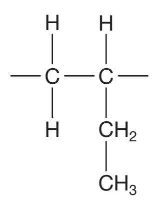
b 

 (2)

5 ▶ a  (2)

b  (1)

6 ▶ a C

b  (1)

c Bromine water stays orange (1) because the polymer is saturated / does not have any C=C double bonds (1).

d Chloroethene (1)