

ST ANDREW'S SECONDARY SCHOOL

NAME			CLASS	
DATE				
CHEM	STRY			6092
	TOPICAL R MULTIPLE-CH	EVISIO OICE C	EVEL IN PACK QUESTIONS	
A B	Kinetic Particle Theory	J K	Salts and Qualitative Analysis Bedox Beactions	
C	Purification and Separation	L	Metals	
D	Elements, Mixtures and Compounds	М	Electrolysis	
Е	Atomic Structure	Ν	The Periodic Table	
F	Ionic Bonding	0	Energy Changes	
G	Covalent and Metallic Bonding	P	Speed of Reaction	
H	The Mole and Chemical Calculations	Q	Ammonia	
ι Ω	Acids and Bases Miscellaneous	К	I ne Atmosphere and Environment	

18 topics of 10 questions + 5 miscellaneous = 185 MCQ!

A Kinetic Particle Theory

- A1 Which changes in pressure and temperature would both result in a decrease in the volume of a fixed mass of gas?
 - **A** Decrease the pressure and decrease the temperature.
 - **B** Decrease the pressure and increase the temperature.
 - **C** Increase the pressure and decrease the temperature.
 - **D** Increase the pressure and increase the temperature.
- A2 Hydrogen sulfide, H₂S, and hydrogen chloride, HC*l*, are both gases at temperatures above -50 °C.

Which gas will diffuse most rapidly at the temperature given?

- A hydrogen chloride at –40 °C
- **B** hydrogen chloride at –20 °C
- C hydrogen sulfide at -40 °C
- D hydrogen sulfide at -20 °C

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A3 Which conditions will give the highest rate of diffusion of a gas?

	molecular mass of gas	temperature
Α	large	high
В	large	low
С	small	high
D	small	low

A4 Ammonia gas is reacted with hydrogen chloride gas using the apparatus shown.

Solid ammonium chloride is produced.



Which statement explains why the solid ammonium chloride is formed nearer to the hydrogen chloride?

- **A** Ammonia solution is a base and hydrogen chloride solution is an acid.
- **B** Ammonia molecules diffuse more slowly than hydrogen chloride molecules.
- **C** Hydrogen chloride has a greater molecular mass than ammonia.
- **D** Hydrogen chloride moves by Brownian motion.
- **A5** The diagram shows a cup of tea.



Which row describes the water particles in the air above the cup compared with the water particles in the cup?

	moving faster	closer together
Α	\checkmark	1
в	\checkmark	×
С	×	1
D	x	x

A6 Hydrogen chloride gas, HCl, reacts with ammonia gas, NH₃, to form solid ammonium chloride.

The apparatus is set up as shown.

After a few minutes, solid ammonium chloride forms where the two gases meet.



The experiment is repeated using hydrogen bromide, HBr, in place of hydrogen chloride.

How far along the tube does the solid ammonium bromide form?



A7 Substance L melts at $-7 \,^{\circ}$ C and is a brown liquid at room temperature.

Which temperature is the boiling point of pure L?

- **A** −77 °C
- **B** $-7 \circ C$ to $+7 \circ C$
- **C** 59°C
- \boldsymbol{D} 107 °C to 117 °C
- **A8** Air is a mixture of gases.

The melting and boiling points of some gases present in clean, dry air are shown.

In the fractional distillation of liquid air, which gas boils first?

	gas	melting point/°C	boiling point/°C
Α	argon	-189	-186
В	krypton	-157	-153
С	nitrogen	-210	-196
D	oxygen	-219	-183

A9 The apparatus shown is set up. After 20 minutes a white ring of ammonium chloride is seen at position Y.



Which statement about the molecules of ammonia and hydrogen chloride is correct?

- A Molecules in ammonia have a larger M_r than molecules of hydrogen chloride and so they move more slowly.
- **B** Molecules in ammonia have a larger M_r than molecules of hydrogen chloride and so they move more quickly.
- **C** Molecules in ammonia have a smaller M_r than molecules of hydrogen chloride and so they move more slowly.
- **D** Molecules in ammonia have a smaller M_r than molecules of hydrogen chloride and so they move more quickly.
- **A10** The melting points and boiling points of the elements of Group I of the Periodic Table are shown.

element	melting point /°C	boiling point /°C
lithium	181	1330
sodium	98	883
potassium	63	759
rubidium	39	688
caesium	28	671

Which pair of elements are liquid at 800 °C?

- A caesium and rubidium
- B potassium and sodium
- C lithium and sodium
- D potassium and caesium



B Experimental Techniques

B1 The diagram shows four pieces of apparatus that are used to measure the volume of a gas or liquid.

Which piece of apparatus should always be filled to the same level?



B2 Copper(II) sulfate is prepared by reacting excess copper(II) carbonate with dilute sulfuric acid.

 $CuCO_3(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + CO_2(g) + H_2O(I)$

Which two pieces of apparatus are needed to obtain copper(II) sulfate crystals by this reaction?

- 1 thermometer
- 2 evaporating basin
- 3 filter funnel
- 4 gas syringe

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

B3 Aqueous sodium thiosulfate reacts with acid to make a precipitate of sulfur.

 $Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(I) + SO_2(g) + S(s)$

A student investigates the effect of temperature on the rate of this reaction.

The student:

- places a piece of paper with a cross on it below the reaction mixture as shown in the diagram
- measures the time taken for the cross to no longer be seen
- repeats the reaction at different temperatures.



Which apparatus is needed for this investigation?

- **A** balance, pipette, stop-clock
- **B** balance, stop-clock, thermometer
- C burette, gas syringe, thermometer
- D measuring cylinder, stop-clock, thermometer
- **B4** An experiment is done to measure the rate of reaction between calcium carbonate and dilute hydrochloric acid. The gas formed is collected in a gas syringe.

Which additional pieces of apparatus are essential to measure how the rate of the reaction changes with temperature and the amount of acid used?

	apparatus to measure temperature	apparatus to measure amount of acid used
Α	balance	thermometer
в	measuring cylinder	balance
С	thermometer	condenser
D	thermometer	measuring cylinder

B5 The diagrams show four pieces of laboratory equipment.



Which equipment is essential to find out if dissolving a salt in water is an exothermic process?

	balance	pipet	stop-watch	thermometer
Α	X	X	X	1
в	\checkmark	X	X	✓
С	X	\checkmark	X	\checkmark
D	1	x	1	x

B6 To prepare dry samples of ammonia and sulfur dioxide in a school laboratory, each gas is passed through a drying agent.

Which drying agent would be used for each of these gases?

	for ammonia	for sulfur dioxide
Α	calcium oxide	calcium oxide
В	calcium oxide	concentrated sulfuric acid
С	concentrated sulfuric acid	calcium oxide
D	concentrated sulfuric acid	concentrated sulfuric acid

B7 The apparatus shows an unsuccessful attempt to prepare and collect dry sulfur dioxide.



Which change would make the experiment successful?

- A omitting flask P
- B omitting flask Q
- C using dilute nitric acid instead of dilute hydrochloric acid
- **D** using sodium sulfate instead of sodium sulfite
- **B8** Which reaction produces a white-coloured substance?
 - A adding water to anhydrous cobalt(II) chloride
 - B adding water to anhydrous copper(II) sulfate
 - C heating hydrated cobalt(II) chloride
 - **D** heating hydrated copper(II) sulfate
- **B9** A student carries out an experiment to find how fast 3 cm pieces of magnesium ribbon dissolve in 10 cm³ samples of sulfuric acid at different temperatures.

Which piece of apparatus does the student not need?

- A balance
- B measuring cylinder
- **C** stop-clock
- D thermometer

B10 Lead(II) iodide is insoluble in water.

Lead(II) iodide is made by adding aqueous lead(II) nitrate to aqueous potassium iodide.

Which pieces of apparatus are needed to obtain solid lead(II) iodide from $20 \, \text{cm}^3$ of aqueous lead(II) nitrate?



C Purification and Separation

C1 A paper chromatography experiment is carried out to find an R_f value for Fe³⁺(aq). The result is shown.



To make the spot containing $Fe^{3+}(aq)$ more visible, the paper is sprayed with aqueous sodium hydroxide so that a precipitate of iron(III) hydroxide forms.

Under the conditions of the experiment, the R_f of Fe³⁺(aq) is given by1.... and the colour of the precipitate is2....

Which row correctly completes gaps 1 and 2?

	gap 1	gap 2
Α	$\frac{x}{y}$	red-brown
в	$\frac{x}{y}$	green
С	$\frac{y}{x}$	red-brown
D	$\frac{y}{x}$	green

- C2 Which statement about methods of purification and analysis is correct?
 - **A** A liquid that boils over a range of temperatures may still be 100% pure.
 - **B** An insoluble substance may be separated from water by crystallisation.
 - **C** Chromatography may only be used to separate coloured substances.
 - **D** Liquid air can be fractionally distilled, giving oxygen as one of the products.
- **C3** River water contains many impurities.

Which process alone can produce pure water from river water?

- A adding chlorine
- B distillation
- **C** filtering
- **D** passing through carbon
- C4 Magnesium hydroxide can be obtained from sea water as shown.



Which process is used in the separation stage to separate solid magnesium hydroxide from the mixture?

- A crystallisation
- **B** filtration
- **C** distillation
- D chromatography





The chromatogram is shown. The diagram is not drawn to scale.

C6 Paper chromatography is done in the same way with three different mixtures of dyes. Each mixture contains at least one of the dyes W, X, Y and Z.

The $R_{\rm f}$ values of the dyes in the three mixtures are shown.

dye	<i>R</i> _f values from mixture 1	<i>R</i> _f values from mixture 2	<i>R</i> _f values from mixture 3
W	0.15	0.15	0.15
X	0.00	0.00	0.00
Y	0.50	0.50	0.50
Z	0.00	0.91	0.91

Which conclusion is correct?

- **A** Dye W is nearest the solvent front and is present only in mixture 1 and mixture 3.
- **B** Dye X has traveled furthest up the chromatography paper.
- **C** Dye Y is the only dye present in all three mixtures.
- **D** Dye Z is nearest the solvent front and is found in only two of the mixtures.

- **C7** Which method can be used to separate a mixture of salt and water to obtain **both** parts of the mixture?
 - A crystallization
 - B distillation
 - **C** evaporation
 - **D** filtration
- C8 Which mixture can be separated into its components by adding water, stirring and filtering?
 - A calcium carbonate and sodium chloride
 - B magnesium and iron
 - **C** sodium chloride and copper(II) sulfate
 - D sulfuric acid and hydrochloric acid
- **C9** The fractional distillation apparatus shown is being used to separate a mixture of two liquids. A thermometer is missing from the apparatus.

Where should the bulb of the thermometer be placed?



- C10 Which process is suitable for obtaining the water from an aqueous solution of sugar?
 - A crystallisation
 - **B** distillation
 - **C** filtration
 - D use of a separating funnel

₹



D1 Which name is given to mixtures of metals?

- A alloys
- B compounds
- C ores
- D salts
- **D2** Copper, iron and zinc are all used as pure metals.

Which of these three metals are also used in alloys?

	$\overline{\mathbb{Q}}$		
	copper	iron	zinc
Α	~	Q	1
В	\checkmark	✓ C	x (
С	x	\checkmark	\checkmark
D	X	X	\checkmark

D3 Propanone, C_3H_6O , is a liquid at room temperature.

What is the boiling point of pure propanone?

- **A** −61 °C to −51 °C
- **B** −56 °C
- **C** 51 °C to 61 °C
- **D** 56 °C
- D4 Which statement about the boxes P, Q and R is correct?



- **A** Box P contains two compounds and box R contains two elements.
- **B** Box P contains two elements and box Q contains a mixture.
- **C** Box P contains two elements and box Q contains one compound.
- **D** Box Q contains two compounds and box R contains a mixture.

- **D5** What is a property of **all** metals?
 - A conduct electricity
 - B hard
 - **C** low melting points
 - D react with water

D6 Which name is given to a pure substance made from more than one type of atom?

- A alloy
- B compound
- **C** element
- D mixture
- **D7** The structure of glycine is shown.



Which row is correct?

	formula of glycine	number of different elements in glycine
Α	CH_5O_2N	10
в	$C_2H_5O_2N$	4
С	$C_2H_5O_2N$	10
D	H₂NCHCOOH	4

D8 Brass is an alloy.

Which statement about brass is correct?

- A It contains a sea of electrons.
- **B** It contains positive and negative ions which are free to move.
- **C** It is a compound of a metal and a non-metal.
- **D** It is a compound of two or more metals.

D9 A hydride is a compound containing **only** two elements, one of which is hydrogen.

Which element can form the greatest number of different hydrides?

- A carbon
- **B** chlorine
- **C** nitrogen
- D oxygen
- D10 Which statement is not correct?
 - A Air is a mixture.
 - **B** Ammonia is a compound.
 - **C** Methane is a compound.
 - **D** Sea water is a compound.

E Atomic Structure

- **E1** Which isotope of an element in the third period of the Periodic Table contains the same number of neutrons as $^{32}_{16}$ S?
 - **A** ²³₁₁Na
 - **B** ²⁴₁₂Mg
 - **C** ²⁸₁₄Si
 - **D** ³¹₁₅P

E2 Which ion has the most shells that contain electrons?

A Al^{3+} **B** Be^{2+} **C** N^{3-} **D** S^{2-}

E3 The diagram shows the relative mass and the relative charge of two particles, O and ●, present in atoms and ions.



Which of these particles are present in a hydrogen atom and in a hydrogen ion?

	Н	H⁺
Α	both \bigcirc and $ullet$	both \bigcirc and $ullet$
в	both \bigcirc and $ullet$	O but not ●
С	● but not O	neither ○ nor ●
D	O but not ●	● but not O

E4 Iodine, I, has a lower relative atomic mass than tellurium, Te, but is placed after it in the Periodic Table.



Which statement explains why iodine is placed after tellurium in the Periodic Table?

- **A** lodine has fewer neutrons than tellurium.
- **B** lodine has fewer protons than tellurium.
- **C** lodine has more neutrons than tellurium.
- **D** lodine has more protons than tellurium.

E5 Which row shows the change that takes place when element X gains the new particle shown?

	particle gained	change
Α	electron	an isotope of element X is formed
в	electron	the element one place to the right of X in the Periodic Table is formed
С	proton	an isotope of element X is formed
D	proton	the element one place to the right of X in the Periodic Table is formed

- E6 Which property is common to ⁴⁰Ca, ³⁹K and ²³Na?
 - **A** Their atoms all have more neutrons than protons.
 - B Their ions all have eight electrons in their outer shell.
 - C They all sink when added to water.
 - **D** They are all deposited at the positive electrode when their molten chloride is electrolysed.
- **E7** Two naturally occurring isotopes of oxygen are 16 O and 17 O.

Which statement is correct?

- A Both isotopes react with iron to form rust.
- **B** Neither isotope reacts with iron to form rust.
- C Only ¹⁶O reacts with iron to form rust.
- **D** Only ¹⁷O reacts with iron to form rust.
- **E8** Symbols representing four particles are shown.

 $^{40}_{20}W$ $^{41}_{20}X^{2+}$ $^{37}_{18}Y$ $^{37}_{17}Z$

The letters are not the chemical symbols.

Which particles have the same number of neutrons?

A W and X^{2+} **B** W and Z **C** X^{2+} and Y **D** Y and Z

E9 The atomic number of cetium, Ce, is 58 A Ce⁴⁺ ion has 140 nucleons in its nucleus. How many protons, neutrons, and electrons are there in one Ce⁴⁺ ion?

////			
	protons	neutrons	electrons
A	58	82//	/54//
В	58	82	62//
C	82	58	54
D	82//	58//	62//

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E10 Two particles, K^+ and Ar, can be written as ${}^{39}_{19}K^+$ and ${}^{40}_{18}Ar$.

Which statement about these particles is correct?

- **A** Ar has more neutrons than K^+ .
- **B** K has more nucleon's than Ar.
- **C** K^+ has 20 electrons.
- **D** K^{+} has a greater mass than Ar.

F Ionic Bonding

F1 - The formula of china clay (aluminium silicate) was shown in an old book as Al2O3.2SiO2.2H2O.- -

 This_fo	ormula_is_s	shown in a h	modern book as At_2	ΘH) _x Ξi ₂ Θ _y		
What a	What are the values of x and y in the modern formula?					
-[
+	X	<u>y</u>				
_ A	2	4				
		5				
	4	 3				
- + - D +	4					

- F2 Which statement about an ionic compound is **not** correct?
 - A It conducts electricity when dissolved in water.
 - **B** It has a high melting point due to strong attractive forces between ions.
 - **C** It has a regular lattice of oppositely charged ions in a 'sea of electrons'.
 - **D** The ionic bonds are formed between metallic and non-metallic elements.
- **F3** Which row describes the structure of the positive ion in sodium chloride?

	protons	electrons	neutrons
Α	11	11	12
В	11	10	12
С	17	17	18
D	17	18	18

- **F4** Which statement describes the structure of an ionic compound?
 - A It is a giant lattice of oppositely charged ions.
 - **B** It is a giant lattice of positive ions in a 'sea' of electrons.
 - **C** It is a giant molecule of oppositely charged ions.
 - **D** It is a simple molecule of oppositely charged ions.

F5 Potassium bromide and methanol are both compounds.

Their melting points are different.

Which row is correct?

	substance with the higher melting point	reason why the melting points are different	
Α	methanol	the attractive forces between oppositely charged ions is greater than the attractive forces between molecules	
В	methanol	the attractive forces between molecules is greater than the attractive forces between oppositely charged ions	
С	potassium bromide	the attractive forces between oppositely charged ions is greater than the attractive forces between molecules	
D	potassium bromide	the attractive forces between molecules is greater than the attractive forces between oppositely charged ions	

F6 What is produced at each electrode when molten rubidium chloride is electrolyzed using platinum electrodes?

	positive electrode	negative electrode
Α	chlorine	hydrogen
В	chlorine	rubidium
С	hydrogen	chlorine
D	rubidium	chlorine

F7 Elements X and Y form an ionic compound, XY.

In which group of the Periodic Table is X found and how is the bond between X and Y formed?

	group in which X is found	how the bond between X and Y is formed
Α	I	by X gaining one electron from Y
в	I	by X transferring one electron to Y
С	VII	by X sharing electrons with Y
D	VII	by X transferring one electron to Y

- **F8** Which statement about solid calcium chloride is correct?
 - A It conducts electricity.
 - **B** It has a low melting point.
 - **C** It has an ionic lattice structure.
 - **D** It is insoluble in water.









G2 Element X has a lattice of positive ions and a 'sea of electrons'.



Which property will X have?

- **A** It conducts electricity by the movement of ions and electrons.
- **B** It has a high melting point.
- **C** It is decomposed by an electric current.
- **D** It is not malleable.
- **G3** Substance **X** has a melting point higher than 500 °C. It is insoluble both in water and in organic solvents. It conducts electricity when both solid and molten.

What is X?

- A copper
- **B** mercury
- **C** poly(ethene)
- D sodium chloride
- G4 How many shared electrons are in one carbon dioxide molecule?

A 2 **B** 4 **C** 8 **D** 12

G5 What is the total number of electrons in one molecule of ammonia, NH₃?

A 6 **B** 8 **C** 10 **D** 11

G6 The diagram shows the structure of a molecule containing atoms of elements X, Y and Z.



- **G7** Three statements about diamond, graphite and silicon(IV) oxide are listed.
 - 1 Diamond and graphite both have giant covalent structures.
 - 2 In silicon(IV) oxide, silicon and oxygen atoms are joined together by covalent bonds throughout the whole structure.
 - 3 Diamond and silicon(IV) oxide have similar structures.

Which statements are correct?

- **A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only
- **G8** Which two molecules contain the same number of electrons?
 - **A** Cl_2 and SO_2
 - ${\bf B} \quad CH_4 \text{ and } H_2O$
 - **C** CO and NH₃
 - **D** CO_2 and HCl
- **G9** Which statement about copper, diamond and silicon(IV) oxide is correct?
 - **A** Copper and silicon(IV) oxide have similar electrical conductivity.
 - **B** In diamond the carbon atoms are covalently bonded as flat sheets.
 - **C** In silicon(IV) oxide the silicon and oxygen atoms are covalently bonded as flat sheets.
 - **D** The structure of copper includes a lattice of positive ions.
- G10 Which row describes the formation of single covalent bonds in methane?

Α	atoms share a pair of electrons	both atoms gain a noble gas electronic structure
В	atoms share a pair of electrons	both atoms have the same number of electrons in their outer shell
С	electrons are transferred from one atom to another	both atoms gain a noble gas electronic structure
D	electrons are transferred from one atom to another	both atoms have the same number of electrons in their outer shell

H The Mole and Chemical Calculations

H1 Ethanol can be made by the reaction shown.

 $C_2H_5Br \ + \ NaOH \ \rightarrow \ C_2H_5OH \ + \ NaBr$

If 5.00 g of C_2H_5Br produces 1.59 g of ethanol, what is the **molar** percentage yield of ethanol? [M_r : C_2H_5Br , 109; C_2H_5OH , 46]

A 13% **B** 32% **C** 42% **D** 75%

H2 Nitrogenous fertilisers promote plant growth and crop yield.

Which compound contains the greatest mass of nitrogen in 100g of fertiliser?

 $\textbf{A} \quad \textbf{KNO}_3 \qquad \textbf{B} \quad \textbf{NH}_4 \textbf{NO}_3 \qquad \textbf{C} \quad (\textbf{NH}_4)_2 \textbf{SO}_4 \qquad \textbf{D} \quad (\textbf{NH}_4)_2 \textbf{HPO}_4$

H3 The relative molecular mass, M_r , of copper(II) sulphate, CuSO₄, is 160.

The relative molecular mass, $M_{\rm r}$, of water is 18.

What is the percentage by mass of water in copper(II) sulphate crystals, CuSO₄.5H₂O?

A $\frac{18 \times 100}{160}$ **B** $\frac{5 \times 18 \times 100}{160 + 18}$ **C** $\frac{18 \times 100}{160 + 18}$ **D** $\frac{5 \times 18 \times 100}{160 + (5 \times 18)}$

H4 The expression shown for the value of A_r for fluorine is incomplete.

How should the gaps in the expression be correctly completed?

	gap 1	gap 2
Α	atom	<u>1</u> 6
В	atom	<u>1</u> 12
С	molecule	<u>1</u> 6
D	molecule	<u>1</u> 12

H5 A mixture of 5 cm^3 of CH_4 and 100 cm^3 of air is exploded. Assume air is 80% N₂ by volume and 20% O₂ by volume. The resulting mixture is cooled. All volumes are measured at room temperature and pressure.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(I)$$

What is the composition of the resulting gas?

	5cm^3 of CO_2	10cm^3 of O_2	80cm^3 of N_2	10 cm ³ of steam
Α	\checkmark	\checkmark	\checkmark	\checkmark
в	\checkmark	\checkmark	\checkmark	x
С	\checkmark	x	\checkmark	\checkmark
D	\checkmark	×	\checkmark	×

H6 Two fertilisers are made by mixing chemical compounds.

Fertiliser X contains 500 g of NH_4NO_3 and 500 g of $(NH_4)_2SO_4$ per kilogram.

Fertiliser Y contains 700 g of NH_4NO_3 and 300 g of $CaSO_4$ per kilogram.

Which fertiliser contains the higher percentage of nitrogen by mass and which contains the higher percentage of sulfur by mass?

	fertiliser with higher percentage N	fertiliser with higher percentage S
Α	Х	х
В	Х	Y
С	Y	Х
D	Y	Y

[M_r: NH₄NO₃, 80; (NH₄)₂SO₄, 132; CaSO₄, 136]

H7 One mole of a sugar, $(CH_2O)_6$, is burned.

Which volume of oxygen, measured at room temperature and pressure, is required for complete combustion of the sugar?

A 24 dm^3 **B** 36 dm^3 **C** 144 dm^3 **D** 216 dm^3

- **H8** Which gas sample contains the most molecules?
 - **A** 24 dm³ of carbon dioxide, CO₂
 - **B** 4 g of hydrogen, H₂
 - **C** 36 dm³ of hydrogen chloride, HCl
 - $\label{eq:D_states} \textbf{D} \quad 14\,g \text{ of nitrogen, } N_2$
- **H9** Ionic metal hydrides react with water.

$$H^- + H_2O \rightarrow OH^- + H_2$$

1.0 g samples of ionic hydrides are separately added to an excess of water.

Which ionic hydride produces the greatest mass of hydrogen gas?

- **A** calcium hydride
- B magnesium hydride
- **C** potassium hydride
- D sodium hydride

H10 12.5 cm^3 of $0.0500 \text{ mol dm}^{-3}$ sodium hydroxide is added to 25.0 cm^3 of $0.100 \text{ mol dm}^{-3}$ hydrochloric acid.

Which concentration of hydrochloric acid remains in the reaction mixture?

- $A = 0.0019 \, mol \, dm^{-3}$
- **B** 0.0333 mol dm⁻³
- **C** 0.0500 mol dm⁻³
- **D** 0.0750 mol dm⁻³

I Acids and Bases

Aluminium sulphate is used in water treatment. Aqueous aluminium sulphate is acidic.

The table shows the results of tests on four different samples of treated water.

To which sample had an excess of aluminium sulphate been added?

sample	pH of sample	reaction with an excess of aqueous ammonia	
Α	3	white precipitate	
В	3	no reaction	
С	7	no reaction	
D	11	white precipitate	

I2 The table gives information about three indicators.

indicator	colour at pH 1	pH at which colour changes	colour at pH 12
thymol blue	red	3	yellow
congo red	blue	5	red
phenolphthalein	colourless	10	red

Which colours would be obtained when each indicator was added separately to pure water?

	thymol blue	congo red	phenolphthalein
Α	red	blue	red
В	yellow	blue	colourless
С	yellow	blue	red
D	yellow	red	colourless

- **I3** Why is ethanoic acid described as a weak acid?
 - A It is an organic acid.
 - **B** It is a poor conductor of electricity.
 - **C** It is only slightly dissociated in water.
 - **D** It reacts only with very reactive metals.
- **I4** Which statement about limestone and lime is correct?
 - A Limestone combines with water to produce slaked lime.
 - **B** Lime is obtained from limestone by oxidation.
 - **C** Lime is used in the desulfurisation of flue gases.
 - **D** Lime is used in the treatment of alkaline soil.
- **I5** Information about two reactions is given.
 - The neutralization reaction between citric acid and sodium hydrogencarbonate is endothermic.
 - The displacement reaction between magnesium and carbon dioxide is exothermic.

Which statements about the two reactions are correct?

- 1 The energy of the products formed in the neutralization reaction is greater than the energy of the reactants.
- 2 The energy of magnesium and carbon dioxide is greater than the energy of magnesium oxide and carbon.
- 3 In an exothermic reaction, the energy required to break the bonds is greater than the energy released when the new bonds are formed.
- **A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only
- **I6** When $BiCl_3$ reacts with water, a white precipitate of BiOCl is formed. The equation for the reaction is shown.

 $BiCl_3(aq) + H_2O(I) \rightleftharpoons BiOCl(s) + 2HCl(aq)$

Which statements are correct?

- 1 The reaction is reversible.
- 2 When dilute hydrochloric acid is added to the reaction mixture, more of the white precipitate forms.
- 3 When aqueous sodium hydroxide is added to the reaction mixture, more of the white precipitate forms.
- **A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

I7 Calcium carbide is an ionic compound in which the oxidation number of carbon is -1.

Calcium carbide reacts with water giving only two products.

What are the formulae of calcium carbide and the two products?

	calcium carbide	products
Α	Ca₂C	CaO + C ₂ H ₄
в	Ca ₂ C	$Ca(OH)_2 + C_2H_2$
С	CaC ₂	CaO + C_2H_4
D	CaC ₂	$Ca(OH)_2 + C_2H_2$

I8 Ethanoic acid reacts with water to produce an acidic solution.

Which row describes the roles of ethanoic acid and water in this reaction?

	ethanoic acid	water
Α	accepts a proton	donates a proton
в	accepts an electron	donates an electron
С	donates a proton	accepts a proton
D	donates an electron	accepts an electron

I9 A few drops of methyl orange are added to a reaction mixture.

During the reaction, a gas is produced and the methyl orange turns from red to orange.

What are the reactants?

- **A** aqueous sodium hydroxide and ammonium chloride
- **B** aqueous sodium hydroxide and calcium carbonate
- C dilute hydrochloric acid and magnesium
- **D** dilute hydrochloric acid and aqueous sodium hydroxide
- **I10** In which row are the oxides correctly identified?

	acidic	basic	
Α	magnesium oxide, calcium oxide	sulfur dioxide, carbon dioxide	
в	magnesium oxide, sulfur dioxide	carbon dioxide, calcium oxide	
С	sulfur dioxide, carbon dioxide	calcium oxide, magnesium oxide	
D	sulfur dioxide, magnesium oxide	calcium oxide, carbon dioxide	

J Salts and Qualitative Analysis

J1 An aqueous solution contains 0.01 mol of $Zn^{2+1}(aq)$ and 0.01 mol of $Cu^{2+1}(aq)$.

Aqueous sodium hydroxide is added until in excess.

After shaking, the mixture is filtered.

What remains on the filter paper?

- A 0.01 mol of a white hydroxide and 0.01 mol of a blue hydroxide
- **B** 0.01 mol of a white hydroxide
- C 0.01 mol of a blue hydroxide



J3

A student adds aqueous sodium hydroxide or aqueous ammonia to aqueous solutions of four different metal compounds.

solution	add a few drops of NaOH(aq)	add excess NaOH(aq)	add a few drops of NH₃(aq)	add excess NH₃(aq)
Α	ppt	ppt dissolves	ppt	ppt dissolves
В	ppt	ppt dissolves	ppt	ppt
С	ppt	ppt	no ppt	no ppt
D	no ppt	no ppt	no ppt	no ppt

Which solution contains Zn²⁺ ions?



What are the results of adding an excess of NaOH(aq) in each experiment?

	experiment 1	experiment 2	
Α	\checkmark	\checkmark	key
В	\checkmark	x	✓ = precipitate remains
С	x	\checkmark	<i>x</i> = precipitate dissolves
D	x	×	

J5 After acidification with dilute nitric acid, a colourless solution of **X** reacts with aqueous silver nitrate to give a white precipitate.

What could **X** be?

- A calcium iodide
- B copper(II) chloride
- C lead(II) iodide
- D sodium chloride

J6 Three test-tubes contain HCl(aq), $H_2SO_4(aq)$ and $HNO_3(aq)$.

The addition of which ions to each test-tube would identify the test-tube containing $H_2SO_4(aq)$?

A $Ba^{2+}(aq)$ **B** $CrO_4^{2-}(aq)$ **C** $CO_3^{2-}(aq)$ **D** $Pb^{2+}(aq)$

J7 A white crystalline material is dissolved in water and the following tests are carried out on the splution.

Ш

test	observation	
addition of NaOH(aq)	a white precipitate which dissolves in an excess of NaOH(aq)	
addition of NH ₃ (aq)	a white precipitate which dissolves in an excess of $NH_3(aq)$	
addition of Ba(NO ₃) ₂ (aq)	a white precipitate which does not dissolve in HNO ₃ (aq)	

What is the white crystalline material?

- A aluminium sulfate
- B magnesium nitrate
- **C** zinc chloride
- D zinc sulfate

J9

J8 The diagram shows some reactions of salt Q.





J10 A mixture of solids is treated with an excess of dilute hydrochloric acid.

A colourless gas is evolved and a white precipitate forms.

What are the solids in the mixture?

- A calcium carbonate and magnesium hydroxide
- B calcium carbonate and magnesium nitrate
- C lead nitrate and calcium hydroxide
- **D** lead nitrate and magnesium carbonate

K Redox Reactions

K1 Many reactions can be classified as redox reactions.

Which equations show redox reactions?

- $1 \quad Mg \ + \ 2HC \it l \ \rightarrow \ MgC \it l_2 \ + \ H_2$
- 2 $2\text{FeC}l_2 + Cl_2 \rightarrow 2\text{FeC}l_3$
- 3 2Na + $Br_2 \rightarrow 2NaBr$
- **A** 1, 2 and 3 **B** 1 and 2 only **C** 2 and 3 only **D** 3 only
 - \rightleftharpoons

 \rightleftharpoons

K2 The equation for a redox reaction is shown.

$$2Fe^{3+}$$
 + Zn \rightarrow $2Fe^{2+}$ + Zn²⁺

Which statements are correct?

- 1 Fe^{3+} is reduced to form Fe^{2+} .
- 2 Zn oxidizes the Fe^{3+} ions.
- 3 Fe³⁺ is an oxidizing agent.
- **A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

K3 An excess of iron(II) chloride is added to acidified potassium manganate(VII).

Which statements are correct?

- 1 The purple color disappears.
- 2 Iron(II) is reduced to iron(III).
- 3 Manganate(VII) ions are oxidized to manganese(II) ions.
- 4 Potassium manganate(VII) is an oxidizing agent.

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4



K4 The compound $YBa_2Cu_3O_7$ is a semi-conductor.

In this compound, the oxidation number of yttrium is +3, barium is +2 and oxygen is -2.

What could be the oxidation numbers of the three copper atoms?

- A
 0
 +2
 +3

 B
 +1
 +2
 +3

 C
 +2
 +2
 +3

 D
 +3
 +3
 +3
- **K5** Sulfur dioxide gas is converted into sulfate ions when it is bubbled into a solution containing aqueous manganate(VII) ions.

$$\begin{split} & \text{SO}_2(g) \ + \ 2\text{H}_2\text{O}(\text{I}) \ \rightarrow \ \text{SO}_4^{2-}(\text{aq}) \ + \ 4\text{H}^+(\text{aq}) \ + \ 2\text{e}^- \\ & \text{MnO}_4^-(\text{aq}) \ + \ 8\text{H}^+(\text{aq}) \ + \ 5\text{e}^- \ \rightarrow \ \text{Mn}^{2+}(\text{aq}) \ + \ 4\text{H}_2\text{O}(\text{I}) \end{split}$$

How will the pH of the reaction mixture change as sulfur dioxide is bubbled at constant rate into a well-stirred solution of manganate(VII) ions until its colour just fades?

- A The pH will decrease.
- **B** The pH will decrease then increase.
- **C** The pH will increase.
- **D** The pH will increase then decrease.
- **K6** A protonated oxoanion of vanadium has been characterised at pH3 with the formula $HV_{10}O_{28}^{5-}$.

Which oxoanion contains vanadium in a **different** oxidation state from that shown in $HV_{10}O_{28}^{5-}$?

A VO_2^+ **B** VO^{2+} **C** $V_4O_{12}^{4-}$ **D** VO_4^{3-}

K7 The thermal decomposition of ammonium nitrate gives only two products, steam and an oxide of nitrogen, **X**.

What is the oxidation number of nitrogen in X?

A +1 **B** +2 **C** +3 **D** +4

K8 Ammonium ions in compounds used as fertilisers are oxidised in air by bacterial action as shown.

 NH_4^+ + $2O_2 \rightarrow NO_3^-$ + $2H^+$ + H_2O

This equation is derived from two half-equations. The half-equation for the conversion of ammonium ions into nitrate ions is as follows.

$$NH_4^+$$
 + $3H_2O \rightarrow NO_3^-$ + $10H^+$ + $8e^-$

What is the half-equation for the oxygen in air being reduced?

- $\mathbf{A} \quad 4\mathrm{e}^{-} + \mathrm{O}_2 + 2\mathrm{H}_2\mathrm{O} \rightarrow 4\mathrm{OH}^{-}$
- $\textbf{B} \quad 4e^- \ \textbf{+} \ \textbf{O}_2 \ \textbf{+} \ \textbf{3H}^+ \ \textbf{\rightarrow} \ \textbf{H}_2\textbf{O} \ \textbf{+} \ \textbf{OH}^-$
- $\textbf{C} \quad 4e^{-} + O_2 + 4H^{+} \rightarrow 2H_2O$
- $\textbf{D} \quad 2e^{-} \ \textbf{+} \ \textbf{O}_2 \ \textbf{+} \ 2\textbf{H}^{+} \ \rightarrow \ \textbf{H}_2\textbf{O}_2$
- **K9** The space shuttle's upward thrust, on lift off, came from the reaction between aluminium and ammonium perchlorate.

$$10Al + 6NH_4ClO_4 \rightarrow 4Al_2O_3 + 2AlCl_3 + 12H_2O + 3N_2$$

Which statement about the overall reaction is correct?

- **A** Aluminium is oxidised, chlorine is oxidised and nitrogen is reduced.
- **B** Aluminium is oxidised, chlorine is reduced and nitrogen is oxidised.
- **C** Aluminium is reduced, chlorine is oxidised and nitrogen is oxidised.
- **D** Aluminium is reduced, chlorine is reduced and nitrogen is oxidised.

K10 Which changes involve reduction?

1
$$2I^- \rightarrow I_2 + 2e^-$$

2 $CuO + H_2 \rightarrow Cu + H_2O$
3 $Al^{3+} + 3e^- \rightarrow Al$
4 $Pb^{2+} + SO_4^{2-} \rightarrow PbSO_4$

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

L Metals

L1 Which diagram correctly shows the conditions necessary for the rusting of iron and also the metal that can be used to prevent rusting by sacrificial protection?



- L2 Three types of steel have different properties.
 - steel 1easily shapedsteel 2brittlesteel 3resistant to corrosion

What are the names of these three types of steel?

	steel 1	steel 2	steel 3
Α	high carbon	mild	stainless
в	high carbon	stainless	mild
С	mild	high carbon	stainless
D	mild	stainless	high carbon

L3 Iron rusts when exposed to oxygen in the presence of water.

Which of these methods will not slow down the rate of rusting of an iron roof?



- L4 Which oxide can be reduced to the metal by hydrogen?
 - A calcium oxide
 - **B** copper(II) oxide
 - **C** magnesium oxide
 - D sodium oxide
- L5 The position of metal **M** in the reactivity series is shown.

K, Na, **M**, A*l*, Zn, Fe, Pb, Cu, Ag

Which method will be used to extract **M** from its ore?

- A electrolysis of its molten oxide
- B electrolysis of its aqueous sulphate
- **C** reduction of its oxide by heating with hydrogen
- D reduction of its oxide by heating with coke
- L6 Metal **M** will displace copper from aqueous copper(II) sulphate solution, but will not displace iron from aqueous iron(II) sulphate solution. **M** is extracted from its oxide by heating the oxide with carbon.

What is the order of reactivity of these four metals?

	least reactive		→ mo:	st reactive
Α	sodium	metal M	iron	copper
В	sodium	iron	metal M	copper
С	copper	iron	metal M	sodium
D	copper	metal M	iron	sodium

L7 Palladium is an element, atomic number 46. Some of its properties, and the properties of its compounds, can be predicted from its position in the Periodic Table.

Which row is correct?

	predicted property of palladium	predicted property of palladium compounds
Α	Its density is similar to the density of sodium.	Some of them can act as catalysts.
В	Its density is similar to the density of sodium.	They are white in the solid state.
С	It is present in compounds in more than one oxidation state.	Some of them can act as catalysts.
D	It is present in compounds in more than one oxidation state.	They are white in the solid state.



- L8 Which statement about an alloy is correct?
 - It is a compound made of two or more elements, one of which is a metal. Α
 - В It is a layer of a metal plated onto another metal.
 - It is a mixture of a metal with other elements. С
 - It is a single element. D
- The properties of four metals are listed. L9
 - Metal W does not react with dilute hydrochloric acid.
 - Metal X reacts with dilute hydrochloric acid.
 - Metal Y displaces metal X from an aqueous solution of its ions. •
 - Metal Z reacts with water and dilute hydrochloric acid. •

What is the order of reactivity of the metals?

	most reactive			least reactive
Α	W	Х	Y	Z
В	W	Y	Х	Z
С	Z	Х	Y	W
D	Z	Y	Х	W

L10 The diagram shows three types of item.



in hospitals

Which method of rust prevention can be used for all three types of item?

- coating with plastic Α
- covering with grease В
- galvanising С
- using stainless steel D

M Electrolysis

M1 Which arrangement is used to electroplate copper onto a steel key?

	electrolyte	anode (positive electrode)	cathode (negative electrode)
Α	aqueous copper(II) sulfate	piece of pure copper	steel key
В	aqueous copper(II) sulfate	steel key	piece of pure copper
С	dilute sulfuric acid	piece of pure copper	steel key
D	dilute sulfuric acid	steel key	piece of pure copper

M2 Aqueous copper(II) sulphate is electrolysed using carbon electrodes.

What happens to the electrolyte?

- A It becomes more acidic.
- B It becomes more alkaline.
- **C** It turns deeper blue.
- **D** It remains unchanged.
- M3 The diagrams show an electrolysis experiment using inert electrodes.



before electrolysis

after electrolysis

What could liquid Y be?

- A aqueous copper(II) sulfate
- B concentrated aqueous sodium chloride
- **C** dilute sulfuric acid
- D ethanol

M4 Which reactions take place during the electrolysis of aqueous copper(II) sulphate with copper electrodes?

	reaction at positive electrode	reaction at negative electrode
Α	$Cu^{2^+} + 2e^- \rightarrow Cu$	$Cu \rightarrow Cu^{2+} + 2e^{-}$
в	$4\text{OH}^{-} \rightarrow 2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^{-}$	$Cu^{2+} + 2e^- \rightarrow Cu$
С	$Cu \rightarrow Cu^{2+} + 2e^{-}$	$2H^{\scriptscriptstyle +} + 2e^{\scriptscriptstyle -} \to H_2$
D	$Cu \rightarrow Cu^{2+} + 2e^{-}$	$Cu^{2+} + 2e^- \rightarrow Cu$

- M5 Which statement about the purification of copper by electrolysis is correct?
 - **A** A pure copper anode is used.
 - **B** A pure copper cathode is used.
 - **C** The colour of the electrolyte fades throughout the process.
 - **D** The electrolyte used is a solution of copper oxide in water.

M6 The diagram shows a simple cell.



M7 The diagram shows a circuit used to electrolyze aqueous copper(II) sulfate.



Which arrows indicate the movement of the copper ions in the electrolyte and of the electrons in the external circuit?

	copper ions	electrons
Α	1	3
В	1	4
С	2	3
D	2	4

M8 During the electrolysis of molten aluminium oxide, Al^{3+} ions are converted to aluminium metal at the cathode.

How many electrons are required to produce 81.0 g of aluminium? [L = the Avogadro constant]

A 9L B 3L C L D	Α	9L	в	3L	С	L	D	$\frac{L}{3}$
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M9 Pairs of metals are connected together to make a simple cell, as shown.



The table shows the reading on the voltmeter when different metals are used.

		metal 2				
		beryllium	cerium	cobalt	manganese	
	beryllium	0.00 V	+0.64 V	–1.57 V	–0.67 V	
al 1	cerium		0.00 V	–2.21 V	–1.30 V	
met	cobalt			0.00 V	+0.90 V	
	manganese				0.00 V	

If metal 2 is more reactive than metal 1, the voltage measured is positive.

The greater the difference in reactivity of the metals, the larger the reading on the voltmeter.

What is the order of reactivity?

	most reactive			least reactive
Α	cerium	beryllium	cobalt	manganese
в	cerium	beryllium	manganese	cobalt
С	cobalt	manganese	beryllium	cerium
D	cobalt	manganese	cerium	beryllium





Which row correctly describes the positive electrode, the negative electrode and the electrolyte?

	positive electrode	negative electrode	electrolyte
Α	nickel spoon	pure nickel	silver nitrate solution
в	nickel spoon	pure silver	nickel nitrate solution
С	pure nickel	nickel spoon	silver nitrate solution
D	pure silver	nickel spoon	silver nitrate solution

N The Periodic Table

N1 Which statement about the properties of some elements is correct?

- **A** All noble gases are unreactive due to having eight electrons in their outer shells.
- **B** The Group VII element astatine, At₂, is expected to be a black solid at room temperature.
- **C** The reactivity of the elements in both Group I and Group VII increases down the group.
- **D** When aqueous chlorine is added to aqueous potassium bromide there is no change in colour.
- N2 In which row of the table are all statements comparing the compounds of calcium and barium correct?

	solubility of calcium hydroxide	solubility of barium hydroxide	thermal stability of calcium carbonate	thermal stability of barium carbonate
Α	higher	lower	higher	lower
В	higher	lower	lower	higher
С	lower	higher	higher	lower
D	lower	higher	lower	higher

N3 Two elements are in the same group of the Periodic Table.

Which property will be the same for both elements?

- A the charge on their ions
- B their electronic structure
- **C** their melting point
- **D** their reactivity with water or acids
- N4 Elements X and Y are in Group VII of the Periodic Table.

X is a liquid at room temperature. **Y** is a solid at room temperature.

- 1 Atoms of **Y** have more protons than atoms of **X**.
- 2 Molecules of **Y** have more atoms than molecules of **X**.
- 3 **Y** displaces **X** from aqueous solutions of \mathbf{X}^- ions.

Which statements are correct?

- A 1 only
- B 2 only
- C 3 only
- **D** 1, 2 and 3
- **N5** The elements sodium to argon form Period 3 of the Periodic Table.

Which row describes the trend across Period 3 from left to right?

	number of outer shell electrons	metallic character	group number
Α	decreases	decreases	decreases
В	decreases	increases	decreases
С	increases	decreases	increases
D	increases	increases	increases

N6 Three different elements react by losing electrons. The ions formed all have the electronic configuration 2,8.

Which statement about these elements is correct?

- **A** They are in the same group.
- **B** They are in the same period.
- **C** They are noble gases.
- **D** They are transition elements.

- **N7** Which statements describe changes that occur from left to right across a period of the Periodic Table?
 - 1 The atomic number of the elements increases.
 - 2 The metallic character of the elements decreases.
 - 3 The physical state of the elements changes from gas to solid.
 - A 2 only B 1 and 2 only C 1 and 3 only D 2 and 3 only
- **N8** An inert gas R is used to fill weather balloons.

Which descriptions of R are correct?

	number of outer shell electrons in atoms of R	structure of gas R
Α	2	diatomic molecules
В	2	single atoms
С	8	diatomic molecules
D	8	single atoms

- **N9** Which statement about an element in the Periodic Table is correct?
 - A Magnesium is a metalloid, has a giant structure and is a good conductor of electricity.
 - **B** Silicon is a metalloid, has a simple molecular structure and is a semi-conductor of electricity.
 - **C** Sodium is a metal, has a giant structure and is a good conductor of electricity.
 - **D** Sulfur is a non-metal, has a giant structure and is a poor conductor of electricity.
- **N10** The bar chart shows the melting points of a series of consecutive elements arranged in order of increasing atomic number. The elements sodium to chlorine form part of this series.

Which bar represents sodium?



O Energy Changes

O1 The diagram shows an energy profile diagram for a chemical reaction.

Which energy change is the activation energy for the catalysed reaction?



O2 The formation of hydrogen iodide from hydrogen and iodine is an endothermic reaction.

 $\mathsf{H}-\mathsf{H} + \mathsf{I}-\mathsf{I} \longrightarrow \mathsf{H}-\mathsf{I} + \mathsf{H}-\mathsf{I}$

What may be deduced from this information?

- A The number of bonds broken is greater than the number of bonds formed.
- **B** The formation of H I bonds absorbs energy.
- **C** The products possess less energy than the reactants.
- **D** The total energy change in bond formation is less than that in bond breaking.
- **O3** The reaction $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$ is exothermic because
 - **A** more bonds are broken than are formed.
 - **B** more bonds are formed than are broken.
 - **C** the energy needed to break the bonds is greater than that released on forming new bonds.
 - **D** the energy needed to break the bonds is less than that released on forming new bonds.





Which statement about this reaction is correct?

- **A** It is endothermic and the activation energy is $\mathbf{P} \mathbf{Q}$.
- **B** It is endothermic and the activation energy is $\mathbf{P} \mathbf{R}$.
- $\label{eq:constraint} \textbf{C} \quad \mbox{ It is exothermic and the activation energy is } \textbf{P} \textbf{Q}.$
- **D** It is exothermic and the activation energy is $\mathbf{P} \mathbf{R}$.

O5 The table shows the energy released by the complete combustion of some compounds.

compound	formula	<i>M</i> _r	∆ <i>H</i> in kJ/mol
benzene	C_6H_6	78	-3270
heptane	C_7H_{16}	100	-4800
octane	C ₈ H ₁₈	114	-5510
propane	C_3H_8	44	-2200

Which compound releases the least energy when 1 g is completely burned?

- A benzene
- B heptane
- **c** octane
- **D** propane

O6 Which gases are used to generate electricity in a fuel cell?

- A carbon dioxide and oxygen
- B hydrogen and methane
- C hydrogen and oxygen
- **D** methane and carbon dioxide

O7 Ethene reacts with hydrogen. The equation is shown.

 $CH_2=CH_2 + H_2 \rightarrow C_2H_6$

The bond energies are shown in the table. The reaction is exothermic.

bond	bond energy in kJ/mol
C–C	+350
C=C	+610
C–H	+410
H–H	+436

What is the energy change for the reaction?

A -560 kJ/mol B -124 kJ/mol C +486 kJ/mol D +5496 kJ/mol

O8 How does a catalyst function?

- A by providing the same reaction pathway and increasing the average energy of the molecules
- **B** by providing an alternative reaction pathway and increasing the average energy of the molecules
- **C** by providing the same reaction pathway with a lower activation energy
- **D** by providing an alternative reaction pathway with a lower activation energy
- **O9** Clouds are formed when water vapour evaporates from the sea.



What is the energy change and what name is given to the type of change when water evaporates?

	energy change	type of change
Α	energy given out	endothermic
В	energy given out	exothermic
С	energy taken in	endothermic
D	energy taken in	exothermic

O10 Statement 1 Hydrogen is used as a fuel.

Statement 2 When hydrogen burns in the air to form water, heat energy is produced.

Which is correct?

- **A** Both statements are correct and statement 2 explains statement 1.
- **B** Both statements are correct but statement 2 does not explain statement 1.
- **C** Statement 1 is correct but statement 2 is incorrect.
- **D** Statement 2 is correct but statement 1 is incorrect.

P Speed of Reaction

P1 The rate of reaction between calcium carbonate and hydrochloric acid is measured in three separate experiments.



In experiment 1, the calcium carbonate is powdered and an excess of hydrochloric acid is used.

In experiment 2, the calcium carbonate is in lumps and an excess of hydrochloric acid is used.

In experiment 3, the calcium carbonate is in lumps but insufficient hydrochloric acid is used.

The results of these experiments are shown.



Which statement is correct?

- A Experiment 1 is shown by curve X.
- **B** Experiment 1 is shown by curve Y.
- **C** Experiment 2 is shown by curve Y.
- **D** Experiment 3 is shown by curve Z.

- **P2** Three experiments are carried out in which the same mass of magnesium is reacted with the same volume of dilute sulfuric acid at room temperature. The magnesium is in excess.
 - experiment 1 Large pieces of magnesium are used.
 - experiment 2 Small pieces of magnesium are used.
 - experiment 3 Large pieces of magnesium are used but the concentration of the acid is increased.

Graphs of the results are shown.



Which row is correct?

	experiment 1	experiment 2	experiment 3
Α	W	Х	Y
В	х	Y	W
С	Y	W	х
D	Y	х	W

P3 A sample of dilute nitric acid is added to lumps of limestone in a conical flask. The conical flask is placed on a balance and the loss in mass is measured.

A second sample of nitric acid of a different concentration is separately tested. All other conditions are kept the same.

The loss in mass in 1 minute at each concentration of nitric acid is shown.

concentration in mol/dm ³	loss in mass in 1 minute / g
0.5	0.15
1.0	0.25

Which row describes and explains the results obtained using 1.0 mol/dm^3 nitric acid compared with 0.5 mol/dm^3 nitric acid?

	description	explanation
Α	decrease in reaction rate	decrease in particle collision energy
В	decrease in reaction rate	increase in particle collision rate
С	increase in reaction rate	increase in particle collision rate
D	increase in reaction rate	increase in particle collision rate and collision energy

P4 Which row describes the effects of increasing both concentration and temperature on the collisions between reacting particles?

	increasing concentration $=$	→ increasing temperature	
Α	more collisions per second only	more collisions per second only	
В	more collisions per second and more collisions with sufficient energy to react	more collisions per second only	
С	more collisions per second only	more collisions per second and more collisions with sufficient energy to react	
D	more collisions per second and more collisions with sufficient energy to react	more collisions per second and more collisions with sufficient energy to react	

- **P5** The effects of a change in conditions on a chemical reaction are listed.
 - 1 The total number of collisions per minute increased.
 - 2 The number of effective collisions per minute increased.
 - 3 The average energy of the particles increased.

Which change in conditions caused all of these effects?

- **A** addition of a catalyst
- **B** increasing the concentration of a solution of a reactant
- **C** increasing the surface area of a solid reactant
- **D** increasing the temperature

P6 A student investigates the rate of reaction between marble chips and hydrochloric acid.

The loss in mass of the reaction flask is measured.

The graph shows the results of two experiments, P and Q.



Which change explains the difference between P and Q?

- **A** A catalyst is added in P.
- **B** A higher temperature is used in P.
- **C** Bigger marble chips are used in Q.
- **D** Hydrochloric acid is more concentrated in Q.
- **P7** The rate of reaction between magnesium ribbon and 2 mol/dm³ hydrochloric acid at 25 °C to produce hydrogen gas is measured.

In another experiment, either the concentration of the hydrochloric acid or the temperature is changed. All other conditions are kept the same.

Which conditions increase the rate of reaction?

- A 1 mol/dm³ hydrochloric acid at 25 °C
- **B** 2 mol/dm³ hydrochloric acid at 10 °C
- C 2 mol/dm³ hydrochloric acid at 20 °C
- $D = 3 \text{ mol}/\text{dm}^3$ hydrochloric acid at $25 \degree \text{C}$

P8 Calcium carbonate reacts with dilute hydrochloric acid to make carbon dioxide gas. Graph X shows the results of this experiment.

The particle size of the calcium carbonate is increased and the experiment is repeated. All other conditions are kept the same. Graph Y shows the results of this experiment.

Which diagram is correct for the two experiments?



P9 Limestone reacts with hydrochloric acid.

Changing which reaction condition does **not** affect the rate of reaction?

A concentration of the acid
B limestone particle size
C pressure
D temperature

P10 Hydrogen peroxide decomposes slowly at room temperature.

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

The reaction can be catalysed by adding manganese($\!IV\!)$ oxide.

The diagram shows the apparatus that can be used to monitor the rate of this reaction.



Which statement is correct when a catalyst is added to the aqueous hydrogen peroxide?

- **A** The catalyst increases the activation energy for the reaction.
- **B** The catalyst is used up during the reaction.
- **C** The gas syringe fills up more quickly when the catalyst is added.
- **D** The total amount of oxygen produced increases when the catalyst is added.

Q Ammonia

Q1 When carbon monoxide reacts with hydrogen, methanol is formed.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

The forward reaction is exothermic.

Which statements are correct?

- 1 There are more moles of gas on the left-hand side of the reaction.
- 2 Increasing the temperature increases the amount of methanol at equilibrium.
- 3 Increasing the pressure increases the amount of methanol at equilibrium.
- 4 Increasing the initial amount of hydrogen decreases the amount of methanol at equilibrium.
- **A** 1 and 2 only **B** 1 and 3 only **C** 2 and 4 only **D** 3 and 4 only

Q2 In the Contact process, sulfur dioxide is converted into sulfur trioxide in a reversible reaction.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The forward reaction is exothermic.

Which conditions give the highest yield of sulfur trioxide at equilibrium?

	pressure / atmospheres	temperature
Α	0.5	high
В	0.5	low
С	1.5	high
D	1.5	low

Q3 Ammonia is manufactured by reacting hydrogen with nitrogen in the Haber process.

Which row describes the sources of hydrogen and nitrogen and the conditions used in the manufacture of ammonia in the Haber process?

	source of hydrogen	source of nitrogen	temperature of reaction/°C	pressure of reaction / atm
Α	air	natural gas	250	2
В	air	natural gas	250	200
С	natural gas	air	450	2
D	natural gas	air	450	200

- Q4 What are the main substances produced by the fractional distillation of liquid air?
 - A oxygen and carbon dioxide
 - **B** oxygen and nitrogen
 - **C** helium and nitrogen
 - D hydrogen and oxygen
- **Q5** The raw materials for the Haber process are hydrogen and nitrogen.

What are the sources of the hydrogen and nitrogen?

- A hydrogen from ethanol and nitrogen from NPK fertilisers
- B hydrogen from methane and nitrogen from air
- C hydrogen from sulfuric acid and nitrogen from air
- D hydrogen from water and nitrogen from ammonium nitrate

Q6 Ammonia is manufactured by the Haber process.

 $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ/mol}$

For this reaction, which rows give a true statement together with a correct reason?

	statement	reason
1	Nitrogen and hydrogen are mixed in the ratio 1:3 by volume.	The formula of ammonia is NH_{3} .
2	The pressure used is approximately 200 atmospheres.	A high pressure is needed to produce a good yield of ammonia at equilibrium.
3	The temperature used is approximately 450 °C.	A high temperature is needed to produce a good yield of ammonia at equilibrium.
4	Vanadium(V) oxide is used as a catalyst.	A catalyst speeds up the rate of the reaction.

A 1 and 2 only **B** 2 and 3 only **C** 3 and 4 only **D** 1, 2 and 3 only

Q7 In which of these equilibria is the forward reaction favoured by an increase in pressure?

- $\mathbf{A} \quad 2\mathrm{HI}(\mathrm{g}) \rightleftharpoons \mathrm{H}_2(\mathrm{g}) + \mathrm{I}_2(\mathrm{g})$
- $\textbf{B} \quad N_2O_4(g) \rightleftharpoons 2NO_2(g)$
- **C** $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$
- **D** $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$
- **Q8** An ammonium salt was added to excess hot aqueous sodium hydroxide. Ammonia gas was evolved. When no more ammonia was evolved, aluminium was added to the solution remaining and more ammonia gas was given off.

What was the ammonium salt?

A NH_4Cl **B** NH_4NO_3 **C** $(NH_4)_2CO_3$ **D** $(NH_4)_2SO_4$

- **Q9** How can the reaction between nitrogen and hydrogen be described?
 - **A** a displacement reaction
 - **B** a neutralisation reaction
 - **C** a precipitation reaction
 - **D** a reversible reaction



What would alter the composition of the equilibrium mixture in favour of the V²⁺ ions?

- A adding an acid
- **B** adding a reagent that selectively precipitates V^{3+} ions
- **C** allowing the hydrogen to escape as it forms
- **D** making the solution more alkaline

R The Atmosphere and Environment

R1 Which row correctly compares carbon dioxide and methane?

	both contain carbon	both are described as a greenhouse gas	both lower the pH of water when they dissolve in it
Α	\checkmark	×	1
В	\checkmark	\checkmark	×
С	x	\checkmark	\checkmark
D	x	\checkmark	X

R2 A catalytic converter in a car exhaust system changes pollutants into less harmful products.

Which change does not occur in a catalytic converter?

- $\textbf{A} \quad \text{carbon dioxide} \rightarrow \text{carbon}$
- $\textbf{B} \quad \text{carbon monoxide} \rightarrow \text{carbon dioxide}$
- $\textbf{C} \quad \text{nitrogen oxides} \rightarrow \text{nitrogen}$
- $\textbf{D} \quad \text{unburned hydrocarbons} \rightarrow \text{carbon dioxide and water}$



Which processes are X and Y?

	Х	Y
Α	combustion	respiration
В	decomposition	respiration
С	photosynthesis	combustion
D	respiration	combustion

R4 Which statements about the carbon cycle are correct?

- 1 Carbon dioxide is added to the atmosphere by respiration.
- 2 Carbon dioxide is added to the atmosphere by combustion of coal.
- 3 Carbon dioxide is removed from the atmosphere by photosynthesis.

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A 1, 2 and 3 B 1 and 2 only C 1 and 3 only D 2 and 3 only
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- **R5** Which compound in polluted air can damage stonework and kill trees?
 - A carbon dioxide
 - B carbon monoxide
 - C lead compounds
 - D sulfur dioxide

R6 Dry air is passed over hot copper until all the oxygen has reacted.



The volume of gas at the end of the reaction is 120 cm^3 .

What is the starting volume of dry air?

- **A** 132 cm³ **B** 152 cm³ **C** 180 cm³ **D** 570 cm³
- **R7** Carbon dioxid

Carbon dioxide and methane are both greenhouse gases which contribute to climate change.

Which statement explains how greenhouse gases contribute to climate change?

- **A** They absorb heat radiation from the Earth.
- **B** They absorb heat radiation from the Sun.
- **C** They absorb light radiation from the Sun.
- D They cause acid rain.
- R8 Lime is used to treat an industrial waste



Which change occurs in the treatment?

	untreated waste		treated waste
Α	acidic	\rightarrow	neutral
В	alkaline	\rightarrow	acidic
С	alkaline	\rightarrow	neutral
D	neutral	\rightarrow	acidic

- **R9** Which statement about air pollutants is **not** correct?
 - A Carbon monoxide is formed from the complete combustion of petroleum.
 - **B** Lead compounds are formed from some types of petrol.
 - **C** Oxides of nitrogen are formed from the combustion reactions inside car engines.
 - **D** Sulfur dioxide is formed from the combustion of coal.

R10 The table shows the composition of exhaust gases from an internal combustion engine.

gas	% of the gas in the exhaust fumes									
gas Y	71									
carbon dioxide	14									
water vapour	13									
carbon monoxide	1									
hydrocarbons	0.3									
nitrogen oxides	0.2									
sulfur dioxide	less than 0.003									

What is gas Y?

- **A** ammonia
- B argon
- **C** chlorine
- D nitrogen

Ω Miscellaneous (aka tough–er questions)

Ω1 Sulfuric acid, one of the most important industrial chemicals, can carry out several functions in chemical reactions.

Three examples of industrial reactions in which sulfuric acid is used are shown below.

reaction 1	$Al_2O_3 + 3H_2SO_4 \to Al_2(SO_4)_3 + 3H_2O$
reaction 2	$Cu + H_2SO_4 \rightarrow CuO + SO_2 + H_2O$
reaction 3	$(CH_3)_3COH + H_2SO_4 \rightarrow (CH_3)_2C=CH_2 + H_2SO_4 + H_2O_4$

What is the function of sulfuric acid in each reaction?

	reaction 1	reaction 2	reaction 3
Α	acidic	oxidising	dehydrating
в	acidic	acidic	dehydrating
С	dehydrating	oxidising	catalytic
D	dehydrating	acidic	catalytic

 Ω^2 When iron reacts with aqueous iron(III) ions, iron(II) ions are formed as the only product.

A final mixture, after the reaction has taken place, contains equal numbers of moles of $Fe^{2+}(aq)$ and $Fe^{3+}(aq)$. Assuming the reaction has gone to completion, how many moles of Fe(s) and $Fe^{3+}(aq)$ were in the starting mixture?

	moles of Fe(s)	moles of Fe ³⁺ (aq)
Α	1	2
в	1	3
С	1	5
D	2	3

Ω3 Antimony can be produced in a two-stage process from its ore stibnite, Sb₂S₃.

The ore is first roasted in oxygen, producing Sb₄O₆ and SO₂.

The Sb_4O_6 is then reduced by carbon, producing Sb and CO_2 .

What volume of CO_2 , measured at room temperature and pressure, is produced on processing 10 moles of Sb_2S_3 ?

- **A** 15 dm³ **B** 180 dm³ **C** 360 dm³ **D** 720 dm³
- **Ω4** In an experiment, 50.0 cm^3 of a $0.100 \text{ mol dm}^{-3}$ solution of a metal nitrate $M(\text{NO}_3)_3$ reacted exactly with 25.0 cm^3 of a $0.100 \text{ mol dm}^{-3}$ solution of sodium sulfite.

During this reaction the sulfite ions were oxidised.



Ω5 Hydrogen can be produced from methane. The two equations shown summarise the reactions involved.

 $CH_4 + H_2O \rightarrow CO + 3H_2$ $CO + H_2O \rightarrow CO_2 + H_2$

What is the total number of molecules of hydrogen that $could be formed from the reaction of 8.000 \times 10^{-3} \text{ g of methane?}$ **A** 3.010 × 10²⁰ **B** 9.030 × 10²⁰ **C** 1.204 × 10²¹ **D** 2.408 × 10²¹

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The volume of one mole of any gas is $24\,dm^3$ at room temperature and pressure (r.t.p.).