8.4 Identification of ions and gases

01. 0620_s21_qp_41 Q: 5

This question is about salts.

(a) Salts that are insoluble in water are made by precipitation.

- Lead(II) iodide, PbI_2, is insoluble in water.
- All nitrates are soluble in water.
- All sodium salts are soluble in water.

You are provided with solid lead(II) nitrate, $Pb(NO_3)_2$, and solid sodium iodide, NaI.

Describe how you would make a pure sample of lead(II) iodide by precipitation.

Your answer should include:
- practical details
- a chemical equation for the precipitation reaction.

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..... [5]

(b) Nitrates decompose when heated.

(i) When hydrated zinc nitrate is heated, oxygen gas is given off.

Describe a test for oxygen.

test .....

observations .....
[2]

(ii) Complete the equation for the decomposition of hydrated zinc nitrate.

$$2Zn(NO_3)_2 \cdot 6H_2O \rightarrow .....ZnO + ...NO_2 + O_2 + ...H_2O$$ [2]

(c) Some sulfates are hydrated.

When hydrated sodium sulfate crystals, $Na_2SO_4 \cdot \boldsymbol{x}H_2O$, are heated, they give off water.

$$Na_2SO_4 \cdot \boldsymbol{x}H_2O(s) \rightarrow Na_2SO_4(s) + \boldsymbol{x}H_2O(g)$$

A student carries out an experiment to determine the value of $\boldsymbol{x}$ in $Na_2SO_4 \cdot \boldsymbol{x}H_2O$.

step 1 Hydrated sodium sulfate crystals are weighed.

step 2 The hydrated sodium sulfate crystals are then heated.

step 3 The remaining solid is weighed.

(i) Describe how the student can check that all the water has been given off.

.....

.....

..... [2]

(ii) In an experiment, 1.61 g of $Na_2SO_4 \cdot xH_2O$ is heated until all the water is given off. The mass of Na_2SO_4 remaining is 0.71 g.

[M_r: Na_2SO_4,142; H_2O,18]

Determine the value of ***x*** using the following steps.

- Calculate the number of moles of Na_2SO_4 remaining.

..... mol

- Calculate the mass of H_2O given off.

..... g

- Calculate the number of moles of H_2O given off.

..... mol

- Determine the value of ***x***.

x = ...
[4]

[Total: 15]

02. 0620_s21_qp_43 Q: 5

This question is about salts.

(a) Salts that are soluble in water can be made by the reaction between insoluble carbonates and dilute acids. Zinc sulfate is soluble in water.

You are provided with solid zinc carbonate, $ZnCO_3$, and dilute sulfuric acid, H_2SO_4.

Describe how you would make a pure sample of zinc sulfate crystals.

Your answer should include:
- practical details
- how you would make sure that all the dilute sulfuric acid has reacted
- a chemical equation for the reaction.

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..... [5]

(b) Some sulfates decompose when heated.

When hydrated iron(II) sulfate is heated strongly, sulfur dioxide gas is given off.

(i) Describe a test for sulfur dioxide.

test .....

observations .....
[2]

(ii) Complete the equation for the decomposition of hydrated iron(II) sulfate.

$$.....FeSO_4 \cdot 7H_2O \rightarrow Fe_2O_3 + SO_2 + SO_3 + ...H_2O$$ [2]

(c) Some chlorides are hydrated.

When hydrated barium chloride crystals, $BaCl_2 \cdot xH_2O$, are heated they give off water.

$$BaCl_2 \cdot xH_2O(s) \rightarrow BaCl_2(s) + xH_2O(g)$$

A student carries out an experiment to determine the value of x in $BaCl_2 \cdot xH_2O$.

step 1 Hydrated barium chloride crystals are weighed.

step 2 The hydrated barium chloride crystals are then heated.

step 3 The remaining solid is weighed.

(i) Describe how the student can be sure that all the water is given off.

.....

.....

..... [2]

(ii) In an experiment, 4.88 g of $BaCl_2 \cdot xH_2O$ is heated until all the water is given off. The mass of $BaCl_2$ remaining is 4.16 g.

[M_r: $BaCl_2$, 208; H_2O, 18]

Determine the value of x using the following steps.

- Calculate the number of moles of $BaCl_2$ remaining.

..... mol

- Calculate the mass of H_2O given off.

..... g

- Calculate the number of moles of H_2O given off.

..... mol

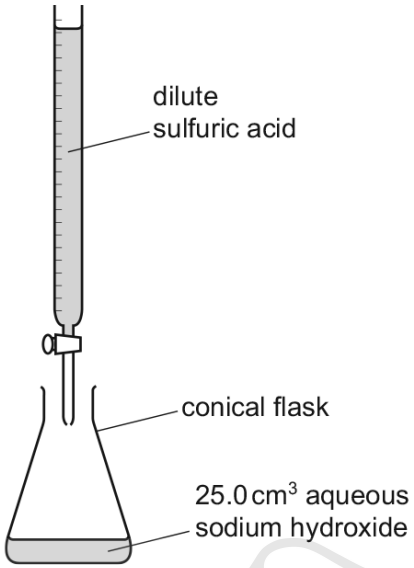
- Determine the value of x.

x = ...
[4]

[Total: 15]

03. 0620_w21_qp_43 Q: 5

(a) Dilute sulfuric acid and aqueous sodium hydroxide can be used to prepare sodium sulfate crystals using a method that involves titration.



(i) Suggest why universal indicator is **not** suitable for this titration.

..... [1]

(ii) Name an indicator that can be used in this titration.

..... [1]

20.0 cm^3 of dilute sulfuric acid neutralises 25.0 cm^3 of 1.00 mol/dm^3 aqueous sodium hydroxide. At the end of the titration the conical flask contains aqueous sodium sulfate with the dissolved indicator as an impurity.

(b) Describe how to prepare a **pure** sample of sodium sulfate crystals from the original solutions of dilute sulfuric acid and aqueous sodium hydroxide of the same concentrations.

You are not required to give details of how to carry out the titration.

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..... [5]

(c) Sodium hydrogensulfate, $NaHSO_4$, dissolves in water to produce an aqueous solution, **X**, containing Na^+, H^+ and SO_4^{2-} ions.

State the observations when the following tests are done.

(i) A flame test is carried out on **X**.

..... [1]

(ii) Copper(II) oxide is warmed with an excess of **X**.

.....

..... [2]

(iii) Acidified aqueous barium nitrate is added to **X**.

..... [1]

[Total: 11]

04. 0620_w19_qp_41 Q: 4

Insoluble salts can be made by precipitation reactions.

A student mixed solutions of some soluble salts.

The results the student obtained are shown in the table.

		second salt solution		
		$Co(NO_3)_2(aq)$	$AgNO_3(aq)$	$Pb(NO_3)_2(aq)$
first salt solution	NaI(aq)	no change	yellow precipitate	yellow precipitate
	$Na_2CO_3(aq)$	purple precipitate	yellow precipitate	white precipitate
	$Na_2SO_4(aq)$	no change	white precipitate	white precipitate

All sodium salts are soluble in water.
Use only results from the table to answer the following questions.

(a) Name:

(i) an insoluble cobalt salt ..... [1]

(ii) an insoluble yellow lead salt. ..... [1]

(b) Write the chemical equation for the reaction in which silver carbonate is formed.

..... [2]

(c) Write the ionic equation for the reaction in which lead(II) iodide is formed.

..... [2]

(d) Aqueous silver nitrate produces a yellow precipitate with both iodide ions and carbonate ions. When testing an unknown solution for iodide ions, the aqueous silver nitrate is acidified.

Explain why the aqueous silver nitrate is acidified.

.....

..... [1]

[Total: 7]

05. 0620_w19_qp_43 Q: 6

This question is about sulfuric acid and substances that can be made from sulfuric acid.

(a) Sulfuric acid is a strong acid.

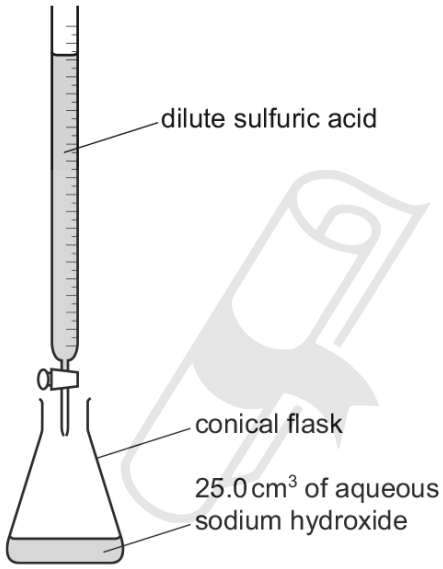
What is meant by the term *strong acid*?

strong .....

acid .....

[2]

(b) Dilute sulfuric acid and aqueous sodium hydroxide are used to make aqueous sodium sulfate, $Na_2SO_4(aq)$, or aqueous sodium hydrogen sulfate, $NaHSO_4(aq)$. The method includes use of the following apparatus.



$25.0\,cm^3$ of aqueous sodium hydroxide of concentration $0.100\,mol/dm^3$ was neutralised by $25.0\,cm^3$ of dilute sulfuric acid of concentration $0.0500\,mol/dm^3$. The equation for the reaction is shown. This is **reaction 1**.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$ **reaction 1**

The same technique and the same solutions can be used to make aqueous sodium hydrogen sulfate. The equation for the reaction is shown. This is **reaction 2**.

$$NaOH(aq) + H_2SO_4(aq) \rightarrow NaHSO_4(aq) + H_2O(l)$$ **reaction 2**

Complete the table to calculate the volume of dilute sulfuric acid that reacts with $25.0\,cm^3$ of aqueous sodium hydroxide in **reaction 2**.

	volume of $0.0500\,mol/dm^3$ dilute sulfuric acid in cm^3	volume of $0.100\,mol/dm^3$ aqueous sodium hydroxide in cm^3
reaction 1	25.0	25.0
reaction 2		25.0

[1]

(c) Aqueous sodium hydrogen sulfate, $NaHSO_4(aq)$, contains the ions $Na^+(aq)$, $H^+(aq)$ and $SO_4^{2-}(aq)$.

Describe what you would **see** if the following experiments were done.

(i) A flame test was done on aqueous sodium hydrogen sulfate.

..... [1]

(ii) Solid copper(II) oxide was added to aqueous sodium hydrogen sulfate and the mixture was warmed.

.....

..... [2]

(d) A test can be done to show the presence of $SO_4^{2-}(aq)$ by adding acidified aqueous barium chloride **or** acidified aqueous barium nitrate.

(i) State the observation that would show that SO_4^{2-} is present.

..... [1]

(ii) Write an ionic equation for the reaction that occurs if SO_4^{2-} is present. Include state symbols.

..... [2]

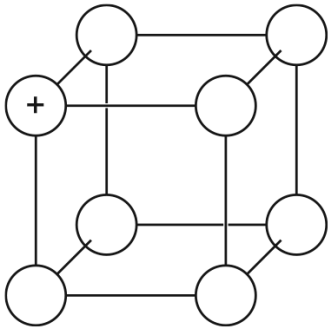
[Total: 9]

06. 0620_m18_qp_42 Q: 2

Sodium chloride is a typical ionic compound.

(a) The diagram shows part of a lattice of sodium chloride.

(i) Complete the diagram to show the ions present. Use '+' for Na^+ ions and '–' for Cl^- ions. One ion has been completed for you.



[2]

(ii) How many electrons does a chloride ion have?

..... [1]

(iii) Identify an element which has atoms with the same number of electrons as a sodium ion.

..... [1]

(b) Electrolysis of concentrated aqueous sodium chloride is an important industrial process.

(i) What is meant by the term *electrolysis*?

.....

..... [2]

(ii) Name the products of the electrolysis of concentrated aqueous sodium chloride.

1 .....

2 .....

3 .....

[3]

(iii) Write an ionic half-equation for the reaction at the cathode.
Include state symbols.

..... [2]

(c) Silver chloride can be made by reacting aqueous sodium chloride with aqueous silver nitrate. The other product of the reaction is sodium nitrate. The chemical equation for the reaction is shown.

$$NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

A student attempted to make the maximum amount of **sodium nitrate** crystals. The process involved three steps.

step 1 The student added aqueous sodium chloride to aqueous silver nitrate and stirred. Neither reagent was in excess.

step 2 The student filtered the mixture. The student then washed the residue and added the washings to the filtrate.

step 3 The student obtained sodium nitrate crystals from the filtrate.

(i) Describe what the student observed in **step 1**.

..... [1]

(ii) Why was the residue washed in **step 2**?

.....

..... [1]

(iii) Give the names of the **two** processes which occurred in **step 3**.

1 .....

2 .....
[2]

(iv) The student started with 20 cm^3 of 0.20 mol/dm^3 $NaCl(aq)$.

- Determine the amount of $NaCl(aq)$ used.

amount of $NaCl(aq)$ used = ... mol

The yield of $NaNO_3$ crystals was 90%.

- Calculate the mass of $NaNO_3$ crystals made.

mass of $NaNO_3$ crystals = ... g
[4]

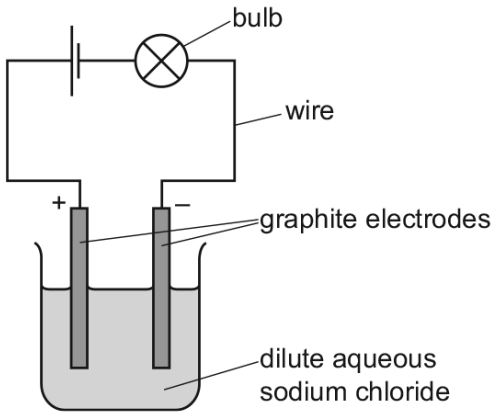
(v) Write a chemical equation for the action of heat on sodium nitrate crystals.

..... [2]

[Total: 21]

07. 0620_w17_qp_42 Q: 4

A student sets up the following electrolysis experiment.



(a) Define the term *electrolysis*.

.....

..... [2]

(b) The student observes bubbles of colourless gas forming at each electrode.

(i) Name the main gas produced at the positive electrode (anode).

..... [1]

(ii) Describe a test for the gas produced in **(b)(i)**.

test .....

result .....
[2]

(iii) Write the ionic half-equation for the reaction taking place at the negative electrode (cathode).

..... [2]

(c) Charge is transferred during electrolysis.

Name the type of particle responsible for the transfer of charge in

the wires, ...

the electrolyte. .....
[2]

(d) The student replaces the dilute aqueous sodium chloride with **concentrated** aqueous sodium chloride.

Suggest **two** differences that the student observes.

1 .....

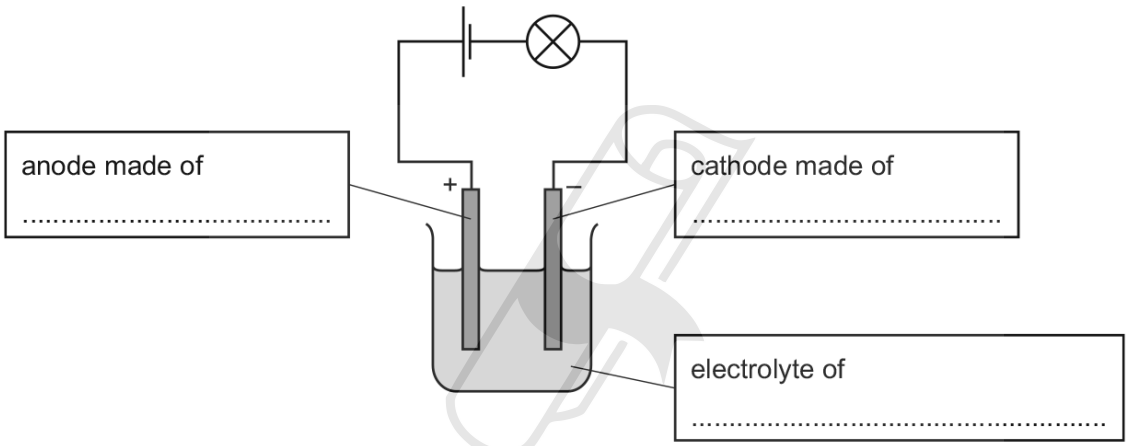
2 .....

[2]

(e) The student has a small piece of impure copper. The main impurities in the copper are small quantities of silver and zinc.

The student uses electrolysis to extract pure copper from the small piece of impure copper.

(i) Complete the labels on the diagram of the student's electrolysis experiment.



[3]

(ii) Use your knowledge of the reactivity series to suggest what happens to the silver and zinc impurities. Explain your answers.

silver impurities .....

.....

.....

zinc impurities .....

.....

.....

[3]

[Total: 17]

08. 0620_s16_qp_42 Q: 4

Hydrogen can be manufactured from methane by steam reforming.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

The reaction is carried out using a nickel catalyst at temperatures between 700 °C and 1100 °C and using a pressure of one atmosphere.

The forward reaction is endothermic.

(a) What is meant by the term *catalyst*?

.....

..... [2]

(b) Suggest **two** reasons why a temperature lower than 700 °C is not used.

.....

..... [2]

(c) Suggest **one** advantage of using a pressure greater than one atmosphere.

..... [1]

(d) Suggest **one** disadvantage of using a pressure greater than one atmosphere.

..... [1]

(e) Hydrogen can also be manufactured by electrolysis. The electrolyte is concentrated aqueous sodium chloride. The electrodes are inert.

The products of electrolysis are hydrogen, chlorine and sodium hydroxide.

(i) Define the term *electrolysis*.

.....

..... [2]

(ii) Name a substance that can be used as the inert electrodes.

..... [1]

(iii) Write an ionic half-equation for the reaction in which hydrogen is produced.

..... [1]

(iv) Where is hydrogen produced in the electrolytic cell?

..... [1]

(v) Describe a test for chlorine.

test .....

result .....
[2]

(f) The electrolysis of concentrated aqueous sodium chloride can be represented by the following word equation.

sodium chloride + water → sodium hydroxide + hydrogen + chlorine

Construct a chemical equation to represent this reaction. Do not include state symbols.

..... [2]

(g) State one use of

chlorine, ...

sodium hydroxide, ...

hydrogen. .....
[3]

[Total: 18]

09. 0620_w16_qp_43 Q: 3

When lead(II) nitrate is heated, two gases are given off and solid lead(II) oxide remains.
The equation for the reaction is shown.

$$2Pb(NO_3)_2(s) \rightarrow 2PbO(s) + 4NO_2(g) + O_2(g)$$

(a) Calculate the M_r of lead(II) nitrate.

..... [1]

(b) 6.62 g of lead(II) nitrate are heated until there is no further change in mass.

(i) Calculate the mass of lead(II) oxide produced.

..... g [2]

(ii) Calculate the volume of oxygen, O_2, produced at room temperature and pressure (r.t.p.).

..... dm^3 [2]

(c) Describe a test for oxygen.

test .....

result .....
[2]

(d) Lead(II) oxide is insoluble. A student adds solid lead(II) oxide to dilute nitric acid until the lead(II) oxide is in excess. Aqueous lead(II) nitrate and water are produced.

(i) What is meant by the term *excess*?

..... [1]

(ii) How would the student know when the lead(II) oxide is in excess?

..... [1]

(iii) Write a chemical equation for the reaction.

..... [1]

[Total: 10]

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01. 0620_s21_ms_41 Q: 5

Question	Answer	Marks
(a)	(add) **water** (to both salts) (1) **dissolve** both salts / make **solutions** (1) **filter** (lead(II) iodide)(1) wash (residue of lead(II) iodide) with **water AND dry** e.g. with filter paper / description of washing and drying (1) $Pb(NO_3)_2 + 2\ NaI \rightarrow 2NaNO_3 + PbI_2$ **OR** $Pb^{2+} + 2I^- \rightarrow PbI_2$ (1)	5
(b)(i)	glowing splint (1) relights / rekindles (1)	2
(b)(ii)	**2**ZnO(s) **and 4**NO2(g) (1) **12**H2O(g) (1)	2
(c)(i)	**heat** again **and weigh** again / repeat steps 2 and 3 (1) until mass is constant (1)	2
(c)(ii)	0.005 (1) 0.9 (1) (0.9 ÷ 18 =) 0.05 (1) (0.05 ÷ 0.005 =) 10 (1)	4

02. 0620_s21_ms_43 Q: 5

Question	Answer	Marks
(a)	add zinc carbonate to sulfuric acid until • it stops dissolving **OR** • no more effervescence (1) filter (zinc carbonate) (1) evaporation of filtrate to form dry crystals (1) $ZnCO_3 + H_2SO_4 \rightarrow ZnSO_4 + CO_2 + H_2O$ CO_2 product in equation (1) rest of equation correct (1)	5
(b)(i)	acidified aqueous potassium manganate(VII) (1) purple to colourless (1)	2
(b)(ii)	**2** $FeSO_4.7H_2O$ (1) **14** H_2O (1)	2
(c)(i)	heat + weigh + repeat (1) until mass is constant (1)	2
(c)(ii)	**M1** 0.02 (1) **M2** 0.72 (1) **M3** M2 ÷ 18 = 0.72/18 = 0.04 (1) **M4** M3 ÷ M1 = 0.04 ÷ 0.02 = 2 (1)	4

03. 0620_w21_ms_43 Q: 5

Question	Answer	Marks
(a)(i)	too many colour changes	1
(a)(ii)	Any acid-base indicator, e.g. methyl orange or phenolphthalein	1
(b)	**M1** repeat without indicator using same volumes **OR** remove indicator by adding charcoal or carbon and filtering (1) **M2** evaporate / heat / warm/ boil/leave in hot place (1) **M3** until most of the water is gone / some water left / saturation(point) / crystallisation (point) / evaporate **some** of the water (1) **M4** cool / leave to crystallise(1) **M5** description of drying (1)	5
(c)(i)	yellow flame	1
(c)(ii)	**M1 solid** dissolves / disappears(1) **M2** blue solution(1)	2
(c)(iii)	white precipitate	1

04. 0620_w19_ms_41 Q: 4

(a)(i)	cobalt carbonate	1
(a)(ii)	lead iodide	1
(b)	$2\ AgNO_3 + Na_2CO_3 \rightarrow Ag_2CO_3 + 2\ NaNO_3$ formula of silver carbonate correct (1) fully correct equation (1)	2
(c)	$Pb^{2+} + 2\ I^- \rightarrow PbI_2$ Pb^{2+} **and** I^- on left of equation (1) fully correct equation (1)	2
(d)	(nitric) acid reacts with / removes carbonate ions	1

05. 0620_w19_ms_43 Q: 6

(a)	strong = exists entirely as ions in solution / fully dissociated 100% dissociated in solution (1) acid = proton donor (1)	2
(b)	50.0 (cm^3)	1
(c)(i)	yellow flame	1
(c)(ii)	solid dissolves / disappears (1) blue solution (1)	2
(d)(i)	white precipitate	1
(d)(ii)	$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ correct ionic equation (1) state symbols (1)	2

06. 0620_m18_ms_42 Q: 2

(a)(i)	M1 correct orientation of '+' and '–' on front four ions M2 rest of structure	2
(a)(ii)	18	1
(a)(iii)	Ne or Neon	1
(b)(i)	M1 breakdown of an ionic compound when molten or in aqueous solution M2 (by the passage of) electricity / electric current / electrical energy	2
(b)(ii)	hydrogen chlorine sodium hydroxide	3
(b)(iii)	$2H^+(aq) + 2e^- \rightarrow H_2(g)$ M1 H^+ on left hand side with e^- added M2 fully correct equation	2
(c)(i)	white precipitate	1
(c)(ii)	to ensure all sodium nitrate / $NaNO_3$ was collected	1
(c)(iii)	M1 evaporation M2 crystallisation	2

(c)(iv)	M1 (moles of NaCl = $0.20 \times 20 \div 1000$ =) $4(.00) \times 10^{-3}$ or 0.004(00) M2 (M_r of $NaNO_3$ =) 85 M3 ($85 \times 4(.00) \times 10^{-3}$ =) 0.34 (g) M4 ($0.34 \times 90 / 100$ =) 0.306 (g) OR 0.31 (g)	4
(c)(v)	$2NaNO_3 \rightarrow 2NaNO_2 + O_2$ M1 = $NaNO_2$ M2 = rest of equation	2

07. 0620_w17_ms_42 Q: 4

(a)	the breakdown (into elements)	1
	of an (ionic) compound by (the passage of) electricity	1
(b)(i)	oxygen	1
(b)(ii)	**glowing** splint	1
	relights	1

(b)(iii)	$2H^+ + 2e^- \rightarrow H_2$ **M1** gain of electrons by H^+ **M2** rest of equation	2
(c)	*the wires:* electrons	1
	the electrolyte: ions	1
(d)	any 2 from: • green gas at positive electrode • bulb is brighter • rate of bubbles increases	2
(e)(i)	*anode made of:* impure copper	1
	cathode made of: (pure) copper	1
	electrolyte of: (aqueous) copper sulfate	1
(e)(ii)	silver (impurities) fall to the bottom of the cell	1
	zinc (impurities) (dissolve) into solution (as ions)	1
	because zinc is more reactive than copper **AND** silver is less reactive than copper	1

08. 0620_s16_ms_42 Q: 4

(a)	**M1** substance that speeds up a reaction/increases rate; **M2** unchanged (chemically) at the end/not used up/lowers activation energy/provides alternative pathway;	**2** 1 1
(b)	**M1** too slow/slower; **M2** lower yield/less product(s)/equilibrium shifts to left/equilibrium shifts in direction of reactants/backward reaction favoured/reverse reaction favoured;	**2** 1 1
(c)	faster/increase rate;	**1**
(d)	lower yield/less product(s)/equilibrium shifts to left/equilibrium shifts in direction of reactants/backward reaction favoured/reverse reaction favoured; **OR** higher cost/expensive; **OR** safety risks;	**1**
(e)(i)	**M1** breakdown of an ionic compound when molten or in aqueous solution; **M2** (using) electricity/electric current/electrical energy;	**2** 1 1
(e)(ii)	carbon/graphite/platinum;	**1**

(e)(iii)	$2H^+ + 2e(^-) \rightarrow H_2$; **OR** $2H_3O^+ + 2e(^-) \rightarrow H_2 + 2H_2O$;	**1**
(e)(iv)	cathode/negative electrode;	**1**
(e)(v)	**M1** damp blue litmus paper; **M2** bleaches/loses colour/turns white/turns colourless;	**2** 1 1
(f)	$2NaCl + 2H_2O \rightarrow 2NaOH + H_2 + Cl_2$ all formulae correct; balancing;	**2**
(g)	**M1** *chlorine*: treating (drinking) water/treating water in swimming pools/kill bacteria in water/chlorination of water/(manufacture of) paper products/plastics/PVC/dyes/textiles/medicines/antiseptics/insecticides/herbicides/fungicides/solvents/paints/disinfectant/bleach/hydrochloric acid; **M2** *sodium hydroxide*: drain cleaner/oven cleaner/extraction of aluminium/purification of bauxite/(manufacture of) biodiesel/paper/soap/detergents/washing powder/textiles/dyes; **M3** *hydrogen*: fuel/rocket fuel/fuel cells/in welding/(manufacture of) ammonia/NH_3/margarine/methanol/hydrochloric acid/refrigerants;	**3** 1 1 1

09. 0620_w16_ms_43 Q: 3

(a)	331	**1**
(b)(i)	**M1** mol = 6.62/331 **OR** 0.02 **M2** 0.02 × 223 = 4.46 (g)	**1** **1**
(b)(ii)	**M1** mol O_2 = 0.02 ÷ 2 **OR** 0.01 **M2** vol = 0.01 × 24 = 0.24 (dm^3)	**1** **1**
(c)	*test:* glowing splint *result:* relights/rekindles	**1** **1**
(d)(i)	more than enough to react (with all the acid) **OR** some lead oxide remains after the reaction **OR** (nitric) acid is limiting	**1**
(d)(ii)	solid stops dissolving	**1**
(d)(iii)	$PbO + 2HNO_3 \rightarrow Pb(NO_3)_2 + H_2O$ **OR** $PbO + 2H^+ \rightarrow Pb^{2+} + H_2O$	**1**