13.1 Carbonates

01. 0620_w21_qp_43 Q: 3

Lead is a metallic element in Group IV. One of the ores of lead is galena, which is an impure form of lead(II) sulfide, PbS.

Lead also occurs in the ore cerussite, which contains lead(II) carbonate, $PbCO_3$.

(a) Calculate the relative formula mass, M_r, of $PbCO_3$.

M_r of $PbCO_3$ = ... [1]

(b) The M_r of PbS is 239.

Calculate the percentage of lead by mass in PbS.

percentage of lead by mass in PbS = ... [1]

(c) The percentage of lead by mass in $PbCO_3$ is 77.5%.

Use this information and your answer to **(b)** to suggest whether it would be better to extract lead from $PbCO_3$ or PbS.

Give a reason for your answer.

....

.... [1]

(d) When lead(II) carbonate is heated it decomposes into lead(II) oxide, PbO, and carbon dioxide.

Write a chemical equation for this reaction.

.... [1]

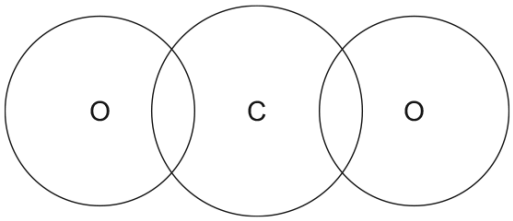
(e) Lead(II) carbonate reacts with dilute nitric acid. One of the products is aqueous lead(II) nitrate, $Pb(NO_3)_2$.

Write a chemical equation for this reaction.

.... [2]

(f) Lead(II) oxide and carbon dioxide are oxides of Group IV elements.

(i) Complete the diagram to show the electron arrangement in one molecule of CO_2. Show only the outer electrons.



[2]

(ii) The melting points of lead(II) oxide and carbon dioxide are shown.

	melting point / °C
lead(II) oxide	886
carbon dioxide	–56

Use your knowledge of structure and bonding to explain why lead(II) oxide has a much higher melting point than carbon dioxide.

Your answer should refer to:

- the types of particles involved
- the relative strength of the forces of attraction between the particles.

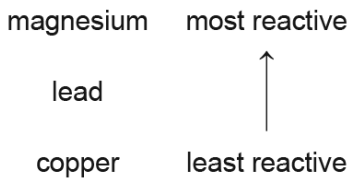
.....

.....

.....

..... [3]

(g) Part of the reactivity series is shown.



Aqueous lead(II) nitrate contains Pb^{2+} ions.

Two experiments are carried out.

In Experiment 1, magnesium is added to aqueous lead(II) nitrate.

In Experiment 2, copper is added to aqueous lead(II) nitrate.

Write an ionic equation for any reaction that occurs in each experiment. If no reaction occurs write 'no reaction'.

Experiment 1 .....

Experiment 2 .....
[2]

(h) When lead(II) nitrate is heated it decomposes to produce the same gaseous products as when copper(II) nitrate is heated.

(i) One of the gaseous products is oxygen.

Describe a test for oxygen.

test .....

observations .....
[2]

(ii) Name the other gaseous product.

..... [1]

[Total: 16]

02. 0620_w19_qp_42 Q: 1

The Periodic Table is very useful to chemists.

Refer only to elements with atomic numbers 1 to 36 in the Periodic Table provided when answering **Question 1**.

(a) Use information from the Periodic Table provided to identify **one** element which:

(i) has atoms with exactly 9 protons ..... [1]

(ii) has atoms with 0 neutrons ..... [1]

(iii) has atoms with exactly 23 electrons ..... [1]

(iv) has atoms with an electronic structure of 2,8,6 ..... [1]

(v) forms ions with a charge of 3– containing 18 electrons ..... [1]

(vi) forms ions with a charge of 2+ containing 10 electrons ..... [1]

(vii) has a relative atomic mass that shows it has at least two isotopes. ..... [1]

(b) State which metal in the first 36 elements:

(i) is the Group I element which reacts most vigorously with water ..... [1]

(ii) reacts with air to form lime. ..... [1]

(c) One element in the first 36 elements is used as the fuel in a fuel cell.

(i) Name this element.

..... [1]

(ii) Write the overall chemical equation for the reaction which occurs when the element in **(c)(i)** reacts in a fuel cell.

..... [2]

[Total: 12]

03. 0620_s18_qp_41 Q: 3

This question is about iron.

(a) Three of the raw materials added to a blast furnace used to extract iron from hematite are coke, hematite and limestone.

Name **one** other raw material added to the blast furnace.

..... [1]

(b) A series of reactions occurs in a blast furnace during the extraction of iron from hematite.

Describe these reactions.
Include:

- **one** chemical equation for the reduction of hematite
- **one** chemical equation for the formation of slag.

.....

.....

.....

.....

.....

.....

.....

..... [5]

(c) The iron extracted from hematite using a blast furnace is impure.

Identify the main impurity in this iron and explain how it is removed in the steel-making process.

main impurity .....

how it is removed .....

.....

.....
[3]

[Total: 9]

04. 0620_s18_qp_43 Q: 6

Calcium chlorate(V), $Ca(ClO_3)_2$, is made by reacting calcium hydroxide with chlorine gas.

$$6Ca(OH)_2 + 6Cl_2 \rightarrow Ca(ClO_3)_2 + 5CaCl_2 + 6H_2O$$

(a) 8.88 g of calcium hydroxide and 7200 cm^3 of chlorine gas are mixed together.

(i) How many moles is 8.88 g of calcium hydroxide?

..... mol [2]

(ii) How many moles of chlorine gas is 7200 cm^3?

..... mol [1]

(iii) What is the maximum **number of moles** of calcium chlorate(V) that can be made from 8.88 g of calcium hydroxide and 7200 cm^3 of chlorine gas?

..... mol [1]

(iv) What is the maximum **mass** of calcium chlorate(V) that can be made from 8.88 g of calcium hydroxide and 7200 cm^3 of chlorine gas?

..... g [2]

The experiment is repeated using different amounts of calcium hydroxide and chlorine gas. The maximum mass of calcium chlorate(V) that can be made in the experiment is 4.84 g.

(v) The actual mass of calcium chlorate(V) made in the experiment is 3.63 g.

Calculate the percentage yield.

percentage yield = ... % [1]

(b) Calcium chlorate(V) undergoes thermal decomposition.

The only products are calcium chloride and a colourless gas.

(i) What must be done to calcium chlorate(V) to make it thermally decompose?

..... [1]

(ii) Write a chemical equation for the thermal decomposition of calcium chlorate(V).

..... [2]

(c) Chloric(V) acid, $HClO_3$, is a strong acid. It can be made from calcium chlorate(V).

(i) What colour is methyl orange indicator in chloric(V) acid?

..... [1]

(ii) Define the term *acid* in terms of proton transfer.

..... [1]

(iii) Complete the chemical equation to show $HClO_3$ behaving as an acid in water.

$$HClO_3 + H_2O \rightarrow \text{.....} + \text{.....}$$

[1]

[Total: 13]

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05. 0620_s17_qp_43 Q: 6

Barium carbonate, $BaCO_3$, is an insoluble solid.

(a) When barium carbonate is heated strongly, it undergoes thermal decomposition. One of the products is barium oxide.

(i) Write a chemical equation for the thermal decomposition of barium carbonate.

..... [1]

(ii) Suggest the pH of the solution formed when barium oxide is added to water.

..... [1]

(iii) Barium nitrate decomposes on heating in the same way as magnesium nitrate decomposes.

Name the **two** gaseous products formed when barium nitrate is heated.

.....

..... [2]

(b) Aqueous sodium carbonate is added to aqueous barium nitrate.

(i) Write a chemical equation for the reaction of aqueous sodium carbonate with aqueous barium nitrate.

..... [2]

(ii) Describe how a pure sample of barium carbonate could be obtained from the resulting mixture.

.....

.....

.....

..... [3]

(c) Barium carbonate reacts with dilute hydrochloric acid.

$$BaCO_3 + 2HCl \rightarrow BaCl_2 + CO_2 + H_2O$$

9.85 g of barium carbonate were added to 250 cm^3 of 1.00 mol/dm^3 hydrochloric acid. This is an excess of hydrochloric acid.

(i) Calculate how many moles of barium carbonate were used in this experiment.

moles of barium carbonate = ... mol [2]

(ii) Deduce how many moles of carbon dioxide were made when all the barium carbonate had reacted.

moles of carbon dioxide = ... mol [1]

(iii) Calculate the volume of carbon dioxide formed in **(c)(ii)** at room temperature and pressure, in dm^3.

volume of carbon dioxide = ... dm^3 [1]

(iv) Calculate how many moles of hydrochloric acid there were **in excess**.

excess moles of hydrochloric acid = ... mol [2]

[Total: 15]

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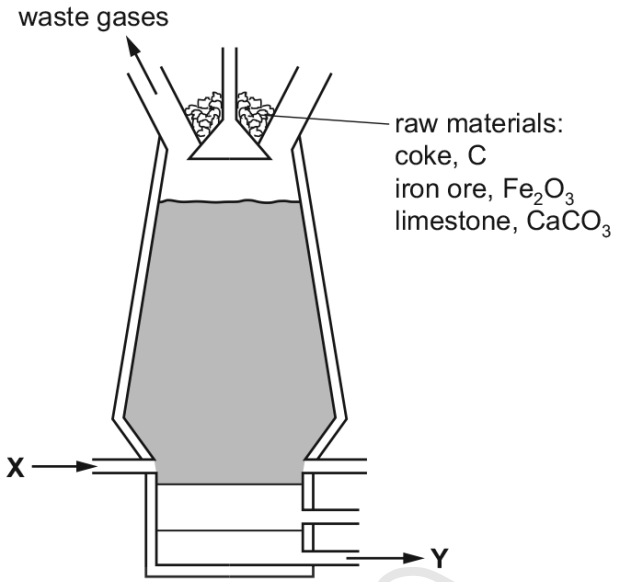
06. 0620_s16_qp_43 Q: 1

The diagram shows a blast furnace.



(a) The following equations represent reactions which take place in the blast furnace.

A $C + O_2 \rightarrow CO_2$

B $CaCO_3 \rightarrow CaO + CO_2$

C $CaO + SiO_2 \rightarrow CaSiO_3$

D $CO_2 + C \rightarrow 2CO$

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

(i) Which reaction is used to increase the temperature inside the blast furnace? ..... [1]

(ii) Which reaction is an example of thermal decomposition? ..... [1]

(iii) In which reaction is carbon both oxidised and reduced? ..... [1]

(iv) Which equation shows the removal of an impurity from the iron? ..... [1]

(v) Which equation shows the reaction of an acidic substance with a basic substance?

..... [1]

(b) Use the diagram of the blast furnace to help you answer these questions.

(i) What enters the blast furnace at **X**?

..... [1]

(ii) What leaves the blast furnace at **Y**?

..... [1]

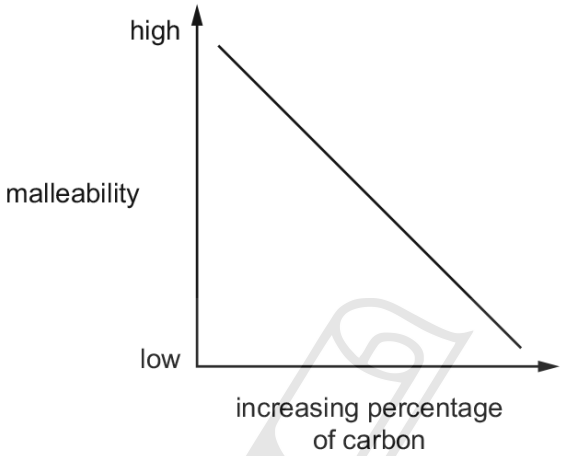
(iii) Name **two** waste gases that leave the blast furnace.

1. .....

2. .....

[2]

(c) The graph shows how the malleability of iron changes as the percentage of carbon in the iron changes.



(i) Describe how the malleability of iron changes as the percentage of carbon changes.

.....

..... [1]

(ii) Iron obtained from the blast furnace contains high levels of carbon.

Explain how the amount of carbon in the iron can be decreased.

.....

.....

..... [2]

[Total: 12]

07. 0620_s15_qp_33 Q: 2

This question is concerned with the following oxides.

aluminium oxide
carbon monoxide
copper(II) oxide
silicon(IV) oxide
sodium oxide
sulfur dioxide
zinc oxide

Choose **one** oxide from the above list to match each of the following descriptions. An oxide may be used once, more than once or not at all.

(a) This oxide does not react with acid or alkali. ..... [1]

(b) This oxide reacts with water to give a strong alkali solution. ..... [1]

(c) This oxide is used as a bleach. ..... [1]

(d) This oxide is amphoteric. ..... [1]

(e) This oxide has a giant covalent structure. ..... [1]

(f) This oxide is soluble in water and it is acidic. ..... [1]

[Total: 6]

08. 0620_s15_qp_33 Q: 3
Quicklime, which is calcium oxide, is made by heating limestone in a furnace.

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$

The reaction does not come to equilibrium.

(a) Suggest why the conversion to calcium oxide is complete.

..... [1]

(b) Calcium hydroxide, slaked lime, is made from calcium oxide.

Write an equation for this reaction.

..... [2]

(c) Calculate the maximum mass of calcium oxide which could be made from 12.5 tonnes of calcium carbonate. 1 tonne = 1×10^6 g.

.....

.....

..... [2]

(d) Limestone is used in agriculture to reduce the acidity of soil and for the desulfurisation of flue gases in power stations.

(i) Most crops thrive in soils whose pH is close to 7. Calcium carbonate, which is insoluble in water, and calcium oxide, which is slightly soluble in water, are both used to reduce the acidity of soils.

Suggest **two** advantages of using calcium carbonate for this purpose.

1. .....

2. ..... [2]

(ii) Explain the chemistry of desulfurisation of flue gases.

.....

.....

.....

..... [3]

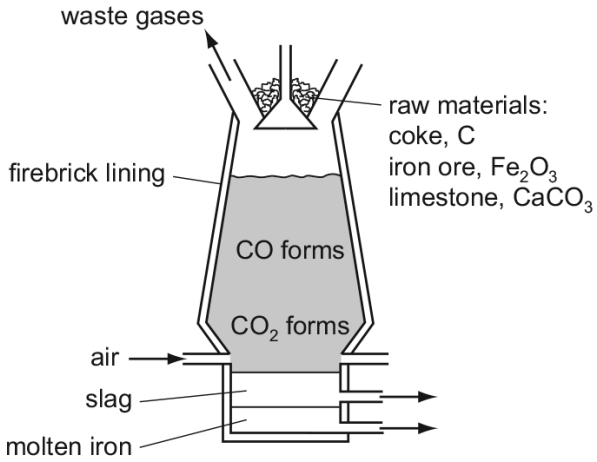
(iii) Give **one** other use of calcium carbonate.

..... [1]

[Total: 11]

09. 0620_w14_qp_31 Q: 4

Iron is extracted from the ore hematite in the Blast Furnace.



(a) The coke reacts with the oxygen in the air to form carbon dioxide.

$$C + O_2 \rightarrow CO_2$$

(i) Explain why carbon monoxide is formed higher in the Blast Furnace.

.....

..... [2]

(ii) Write an equation for the reduction of hematite, Fe_2O_3, by carbon monoxide.

..... [2]

(b) (i) Limestone decomposes to form two products, one of which is calcium oxide. Name the other product.

..... [1]

(ii) Calcium oxide reacts with silicon(IV) oxide, an acidic impurity in the iron ore, to form slag. Write an equation for this reaction.

..... [2]

(iii) Explain why the molten iron and the molten slag form two layers and why molten iron is the lower layer.

.....

..... [2]

(iv) Suggest why the molten iron does **not** react with the air.

..... [1]

(c) Iron and steel rust. Iron is oxidised to hydrated iron(III) oxide, $Fe_2O_3.2H_2O$, which is rust.

(i) Name the **two** substances which cause iron to rust.

..... [1]

(ii) Explain why an aluminium article coated with aluminium oxide is protected from further corrosion but a steel article coated with rust continues to corrode.

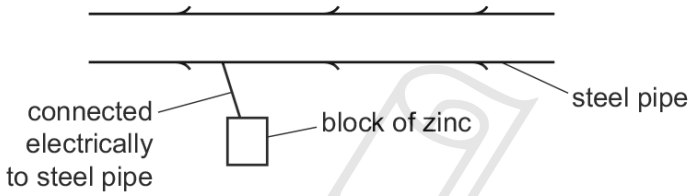
.....

..... [1]

(d) There are two electrochemical methods of rust prevention.

(i) The first method is sacrificial protection.

Explain why the steel article does not rust.



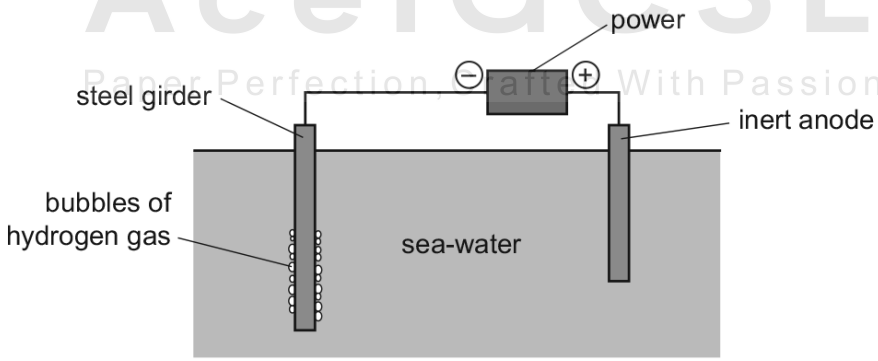
.....

.....

.....

..... [4]

The second method is to make the steel article the cathode in a circuit for electrolysis.



(ii) Mark on the diagram the direction of the electron flow. [1]

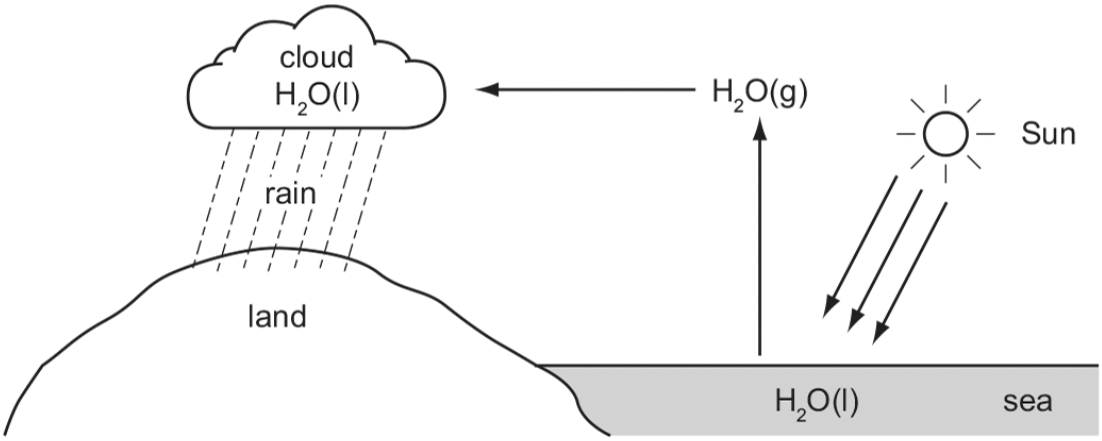
(iii) The steel girder does not rust because it is the cathode. Reduction takes place at the cathode. Give the equation for the reduction of hydrogen ions.

..... [2]

[Total: 19]

10. 0620_s12_qp_31 Q: 1

The diagram below shows part of the Water Cycle.



(a) (i) State the name of each of the following changes of state.

$$H_2O(l) \rightarrow H_2O(g)$$

name .....

$$H_2O(g) \rightarrow H_2O(l)$$

name .....

[2]

(ii) Which **one** of the above changes of state is exothermic? Explain your choice.

.....

..... [1]

(b) The rain drains into rivers and then into reservoirs. Describe how water is treated before it enters the water supply.

.....

..... [2]

(c) (i) Explain how acid rain is formed.

.....

.....

.....

..... [4]

(ii) Fish live in water which is neutral (neither acidic nor alkaline). Acid rain decreases the pH of water in lakes and rivers. Both of the bases, calcium oxide and calcium carbonate, can neutralise this acid and increase the pH. Explain why calcium carbonate is a better choice.

.....

..... [2]

[Total: 11]

01. 0620_w21_ms_43 Q: 3

Question	Answer	Marks
(a)	267	1
(b)	(207 / 239 × 100 =) 86.6%	1
(c)	PbS because the percentage of lead is larger in PbS **or** answer to **(b) >** 77.5%	1
(d)	$PbCO_3 \rightarrow PbO + CO_2$	1
(e)	$PbCO_3 + 2HNO_3 \rightarrow Pb(NO_3)_2 + H_2O + CO_2$	2
(f)(i)	**M1** two double bonds (1) **M2** two pairs of non-bonding electrons on each oxygen and no non-bonding electrons on carbon (1)	2
(f)(ii)	**M1** bonds between ions **or** ionic bonds in lead(II) oxide (1) **M2** attraction **between molecules** in carbon dioxide (1) **M3** weaker attraction (between particles) in carbon dioxide **ORA** (1)	3
(g)	**M1** $Mg + Pb^{2+} \rightarrow Mg^{2+} + Pb$ (1) **M2** no reaction (1)	2

Question	Answer	Marks
(h)(i)	**M1** glowing splint (1) **M2** relights (1)	2
(h)(ii)	nitrogen dioxide / nitrogen(IV) oxide	1

02. 0620_w19_ms_42 Q: 1

(a)	fluorine / F	1
(a)(ii)	hydrogen / H	1
(a)(iii)	vanadium / V	1
(a)(iv)	sulfur / S	1
(a)(v)	phosphorus / P	1
(a)(vi)	magnesium / Mg	1
(a)(vii)	chlorine / Cl	1
(b)(i)	potassium / K	1
(b)(ii)	calcium / Ca	1
(c)(i)	gydrogen / H	1
(c)(ii)	$2H_2 + O_2 \rightarrow 2H_2O$ water as product from reaction of hydrogen and oxygen (1) balanced (1)	2

03. 0620_s18_ms_41 Q: 3

(a)	(hot) air	1
(b)	coke is burned (to form carbon dioxide) **OR** $C + O_2 \rightarrow CO_2$	1
	carbon dioxide is reduced by (more) coke to form **carbon monoxide** or **CO** **OR** $C + CO_2 \rightarrow 2CO$	1
	$3CO + Fe_2O_3 \rightarrow 2Fe + 3CO_2$	1
	limestone (decomposes to) form lime / CaO / calcium oxide (and carbon dioxide) **OR** $CaCO_3 \rightarrow CaO + CO_2$	1
	$CaO + SiO_2 \rightarrow CaSiO_3$	1
(c)	the impurity is C	1
	blow **into** or pass oxygen **through** (molten) **iron**	1
	carbon dioxide escapes or carbon dioxide is a gas	1

04. 0620_s18_ms_43 Q: 6

(a)(i)	74	1
	0.12	1
(a)(ii)	0.3	1
(a)(iii)	0.02	1
(a)(iv)	207	1
	4.14	1
(a)(v)	75%	1
(b)(i)	heat it	1
(b)(ii)	$Ca(ClO_3)_2 \rightarrow CaCl_2 + 3O_2$ 1 mark for O_2 as product 1 mark for the rest correct and balanced	2
(c)(i)	red	1
(c)(ii)	proton donor	1
(c)(iii)	$\rightarrow ClO_3^- + H_3O^+$	1

05. 0620_s17_ms_43 Q: 6

(a)(i)	$BaCO_3 \rightarrow BaO + CO_2$	1
(a)(ii)	anything pH in the range pH 10 to pH 14	1
(a)(iii)	nitrogen dioxide	1
	oxygen	1
(b)(i)	$Na_2CO_3 + Ba(NO_3)_2 \rightarrow BaCO_3 + 2NaNO_3$ **M1** formula of $NaNO_3$ **M2** equation fully correct	2
(b)(ii)	filter	1
	wash (the residue) using water	1
	dry the residue between filter papers / in a warm place	1
(c)(i)	M_r = 197	1
	(9.85 / 197 =) 0.05 (mol)	1
(c)(ii)	0.05 (mol)	1
(c)(iii)	(0.05 □ 24) = 1.2 (dm_3)	1
(c)(iv)	moles of HC*l* at the start = (250 / 1000 □ 1.00) = 0.25	1
	moles HC*l* in excess = 0.25 – (2 □ 0.05) = 0.15 (mol)	1

06. 0620_s16_ms_43 Q: 1

(a)(i)	A;	1
(a)(ii)	B;	1
(a)(iii)	D;	1
(a)(iv)	C;	1
(a)(v)	C;	1
(b)(i)	(hot) air;	1
(b)(ii)	(molten) iron;	1
(b)(iii)	any 2 from: carbon dioxide; carbon monoxide; nitrogen;	2
(c)(i)	as the percentage of carbon increases, so the malleability decreases;	1
(c)(ii)	**M1** oxygen (gas) blown in; **M2** carbon dioxide formed / $C + O_2 \rightarrow CO_2$;	2 1 1

07. 0620_s15_ms_33 Q: 2

(a)	carbon monoxide;	1	**A** CO
(b)	sodium oxide;	1	**A** Na_2O
(c)	sulfur dioxide;	1	**A** SO_2
(d)	zinc oxide **OR** aluminium oxide;	1	**A** ZnO or Al_2O_3
(e)	silicon(IV) oxide;	1	**A** silicon (di)oxide or SiO_2
(f)	sulfur dioxide;	1	**A** SO_2

08. 0620_s15_ms_33 Q: 3

(a)	carbon dioxide escapes / leaves / lost / released **OR** not a closed system;	**1**	**A** gas escapes / leaves / lost / released
(b)	$CaO + H_2O \rightarrow Ca(OH)_2$ reactants; product;	**2**	One mark for each side correct **A** multiples **I** state symbols
(c)	M1 number of moles of $CaCO_3$ = (12.5 / 100 =) 0.125 **or** 125000 **OR** 56 / 100 = 0.56; M2 mass calcium oxide = (0.125 × 56) = 7 (tonnes) **OR** 0.56 × 12.5 = 7;	**2**	Correct answer scores both marks **A** answers in g or kg
(d)(i)	*Any **two** from:* does not wash away / insoluble / lasts a long time; does not increase pH above 7 / neutral / has pH 7; naturally occurring / does not need to be processed;	**2**	**A** does not leach out
(d)(ii)	*Any **three** from:* (flue gas contains) sulfur dioxide; flue gas / sulfur dioxide is acidic; calcium carbonate reacts with sulfur dioxide; to make a salt / calcium sulfite **OR** neutralisation;	**3**	**A** $CaCO_3$ is a base
(d)(iii)	making steel or iron / in a blast furnace / toothpaste / (making) glass / building / (making) cement / treating acidic river or lakes / chalk;	**1**	

09. 0620_w14_ms_31 Q: 4

(a) (i) insufficient/limited oxygen [1]
or $2C + O_2 \rightarrow 2CO$

coke/carbon reacts with carbon dioxide [1]
or $C + CO_2 \rightarrow 2CO$

(ii) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
species (1) balancing (1) [2]

(b) (i) carbon dioxide [1]

(ii) $CaO + SiO_2 \rightarrow CaSiO_3$ [2]
[1] each side correct

(iii) (molten) iron higher density (than slag) [2]

(iv) No oxygen in contact with iron **or** layer of slag prevents hot iron reacting with oxygen/air **or** (all) oxygen reacts with carbon (so no oxygen left to react with iron) [1]

(c) (i) air/oxygen and water (need both) [1]

(ii) aluminium oxide layer is impervious **or** non-porous **or** passive **or** unreactive **or** will not allow water/air to pass through it (rust allows passage of water **or** air **or** it flakes off) [1]

(d) (i) zinc more reactive (than iron/steel) [1]
loses electrons [1]
electrons move (from zinc) to iron [1]
Zinc reacts (with air and water) **or** zinc corrodes **or** zinc is oxidised **or** zinc is anodic **or** zinc forms positive ions **or** zinc forms Zn^{2+} **or** iron and steel don't react with air/water **or** iron and steel are not oxidised **or** iron and steel do not form ions **or** iron and steel do not lose electrons **or** iron and steel are cathodic [1]

(ii) R to L in wire [1]

(iii) $2H^+ + 2e^- \rightarrow H_2$
species (1) balancing (1)

[Total: 19]

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10. 0620_s12_ms_31 Q: 1

(a) (i) evaporation / boiling / vaporisation / evaporate / vaporise; [1]
condensation / liquefaction / condense / liquefy; [1]

(ii) condensation **accept:** correct equation $H_2O_{(g)} \rightarrow H_2O_{(l)}$
because energy / heat is given out / gas has more energy than liquid / need to supply energy to change liquid to gas so reverse must give out energy / bonds form; [1]

(b) chlorination / chlorine to kill microbes; [1]

filtration or filter; [1]
accept: sedimentation or sand or gravel or grit

(c) (i) combustion of fossil fuels; [1]
(which contain) sulfur; [1]
sulfur dioxide formed; [1]
(reacts in air / with water to form) **sulfurous / sulfuric acid**; [1]
OR
nitrogen and oxygen in air; [1]
react at high temperatures / in engines; [1]
to form oxides of nitrogen **or** named oxide of nitrogen; [1]
(reacts in air / with water to form) nitrous / nitric acid; [1]
[max 4]

(ii) calcium oxide is soluble in water / reacts with water to form calcium hydroxide; [1]
pH above 7 / the water becomes alkaline; [1]
OR
calcium carbonate insoluble in water; [1]
pH cannot be above 7 / water is neutral / does not make water alkaline; [1]
[max 2]

[Total: 11]