10.4 Uses of metals

01. 0620_s20_qp_43 Q: 7

Aluminium is extracted by electrolysis. Iron is extracted from its ore by reduction with carbon.

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

.....

..... [2]

(b) Name the main ore of aluminium.

..... [1]

(c) **(i)** Explain why aluminium **cannot** be extracted by reduction with carbon.

..... [1]

(ii) Describe the role of cryolite in the extraction of aluminium by electrolysis.

..... [1]

(iii) Name the product formed at the positive electrode.

..... [1]

(iv) Write the ionic half-equation for the reaction at the negative electrode.

..... [2]

(d) Aluminium is used in overhead electricity cables.

Give **two** properties of aluminium that make it suitable for use in overhead electricity cables.

1 .....

2 .....

[2]

(e) Iron is a transition element.

(i) Iron forms hydrated iron(III) oxide when it rusts.

Write a word equation to represent the formation of rust.

..... [2]

(ii) Give **two** ways in which the properties of transition elements differ from the properties of Group I metals.

1 .....

2 .....
[2]

[Total: 14]

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02. 0620_w20_qp_41 Q: 2

Zinc is extracted from an ore containing zinc sulfide.

(a) State the name of this zinc ore.

..... [1]

(b) This ore is converted to zinc oxide, ZnO.

Zinc oxide is then reacted with carbon.

(i) Write a chemical equation for the reaction of zinc oxide with carbon.

..... [1]

(ii) State what type of chemical change happens to the zinc in zinc oxide in this reaction.

Explain your answer.

chemical change .....

explanation .....

.....

.....

[2]

(iii) Explain why aluminium is **not** extracted from aluminium oxide by heating with carbon.

.....

..... [1]

(iv) Suggest an alternative method for the extraction of zinc from zinc oxide.

..... [1]

(c) Brass is an alloy of zinc.

Explain, in terms of particles, why brass is harder than pure zinc.

.....

.....

.....

.....

..... [3]

[Total: 9]

03. 0620_w20_qp_42 Q: 3

Group I metals are very reactive. Transition elements are also metals but are less reactive than Group I metals.

(a) State **two** physical properties of Group I metals which are similar to those of transition metals.

1 .....

2 .....

[2]

(b) Describe **two** ways in which the physical properties of Group I metals are different from those of transition metals.

1 .....

.....

2 .....

.....

[2]

(c) When Group I metals are added to water they fizz and an alkaline solution forms.

(i) Name the gas given off.

..... [1]

(ii) Identify the ion present in the solution which makes the solution alkaline.

..... [1]

(iii) Write the chemical equation for the reaction between sodium and water.

..... [2]

(d) When the transition element iron is added to water the iron rusts.

When an iron object is coated with a layer of zinc, rusting is prevented.

(i) Name this process of coating iron objects with a layer of zinc.

..... [1]

(ii) Explain how completely coating an iron object with a layer of zinc prevents rusting.

..... [1]

(iii) Rusting of iron ships can be prevented by attaching zinc blocks to the hull of the ship.

Explain how this prevents rusting.

.....

..... [2]

[Total: 12]

04. 0620_w16_qp_42 Q: 6

Aluminium is a very important metal.

Aluminium is extracted from its ore, bauxite, by electrolysis. Bauxite is an impure form of aluminium oxide, Al_2O_3.

(a) Describe how aluminium is extracted from **bauxite**. Include an ionic half-equation for the reaction at each electrode.

description .....

.....

.....

.....

.....

.....

.....

.....

ionic half-equation for the anode reaction .....

ionic half-equation for the cathode reaction.....
[5]

(b) Explain why the anodes have to be replaced regularly.

.....

..... [2]

(c) Give **two** uses of aluminium and give a reason why aluminium is suitable for each use.

use 1 .....

reason .....

use 2 .....

reason .....
[4]

[Total: 11]

05. 0620_s15_qp_31 Q: 2

Iron from the Blast Furnace is impure. It contains about 5% of impurities, mainly carbon, sulfur, silicon and phosphorus, which have to be removed when this iron is converted into steel.

(a) Explain how the addition of oxygen and calcium oxide removes these impurities. Include an equation for a reaction of oxygen and a word equation for a reaction of calcium oxide in this process.

.....

.....

.....

.....

.....

.....

[5]

(b) Mild steel is the most common form of steel. Mild steel contains a maximum of 0.3% of carbon.

High carbon steel contains 2% of carbon. It is less malleable and much harder than mild steel.

(i) Give a use of mild steel.

..... [1]

(ii) Suggest a use of high carbon steel.

..... [1]

(iii) Explain why metals are malleable.

.....

.....

.....

..... [3]

(iv) Suggest an explanation why high carbon steel is less malleable and harder than mild steel.

.....

.....

..... [2]

[Total: 12]

06. 0620_s14_qp_31 Q: 5

Zinc is obtained from the ore, zinc blende, ZnS.

(a) Describe the extraction of zinc from its ore, zinc blende. Include at least one balanced equation in your description.

.....

.....

.....

.....

..... [5]

(b) State **two** major uses of zinc.

.....

..... [2]

[Total: 7]

07. 0620_s14_qp_33 Q: 4

Iron from a blast furnace contains about 5% of the impurities – carbon, silicon, phosphorus and sulfur. Most of this impure iron is used to make steels, such as mild steel, and a very small percentage is used to make pure iron.

(a) Calcium oxide and oxygen are used to remove the impurities from the iron produced in the blast furnace.

(i) State how these chemicals are manufactured.

calcium oxide .....

.....

oxygen .....

.....

[3]

(ii) Describe how these two chemicals remove the four impurities. Include at least one equation in your answer.

.....

.....

.....

.....

.....

.....

..... [5]

(b) (i) Describe the structure of a typical metal such as iron. You may include a diagram.

.....

.....

[2]

(ii) Explain why pure iron is malleable.

.....

..... [2]

(iii) Mild steel is an alloy of iron and carbon.
Suggest why mild steel is harder than pure iron.

.....

.....

..... [2]

[Total: 14]

08. 0620_w14_qp_32 Q: 2

Aluminium is obtained by the reduction of aluminium ions to aluminium atoms.

(a) Write an ionic equation for the reduction of an aluminium ion to an aluminium atom.

..... [2]

(b) The original method of extracting aluminium involved the reduction of aluminium chloride using the reactive metal sodium. Aluminium obtained by this method was very expensive due to the high cost of extracting sodium from sodium chloride.

(i) Complete the equation for this reduction.

$$AlCl_3 + ...Na \rightarrow ..... + ...$$

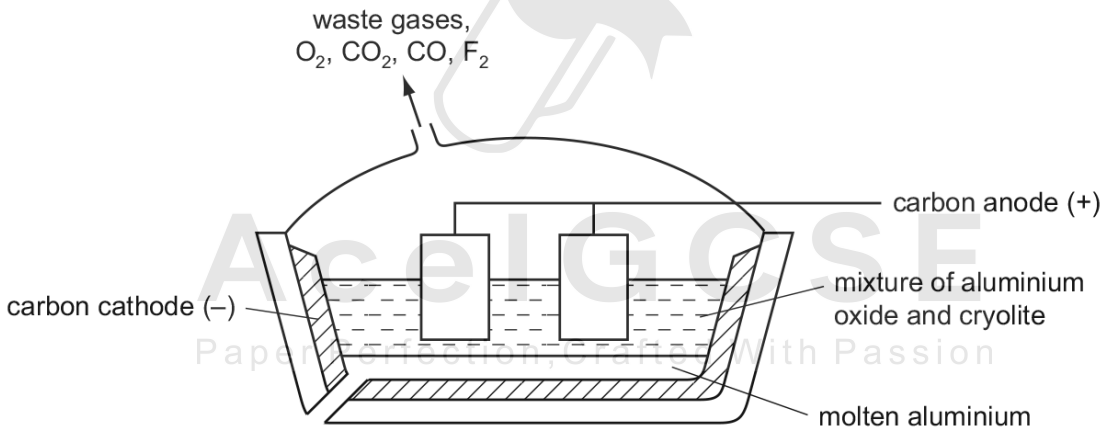
[2]

(ii) How can sodium metal be obtained from sodium chloride?

.....

..... [2]

(c) In the modern method, aluminium is obtained by the electrolysis of aluminium oxide (alumina) dissolved in molten cryolite, Na_3AlF_6.



(i) The major ore of aluminium is impure aluminium oxide.
What is the name of this ore?

..... [1]

(ii) This ore is a mixture of aluminium oxide, which is amphoteric, and iron(III) oxide which is basic.
Explain how these two oxides can be separated by the addition of aqueous sodium hydroxide.

.....

.....

..... [2]

(iii) Give **two** reasons why the electrolyte contains cryolite.

.....

.....

..... [2]

(iv) The mixture of gases evolved at the positive electrode includes:

carbon dioxide
carbon monoxide
fluorine
oxygen

Explain the presence of these gases in the gaseous mixture formed at the positive electrode. Include at least **one** equation in your explanation.

.....

.....

.....

.....

..... [5]

(d) A major use of aluminium is the manufacture of pots and pans. One reason for this is its resistance to corrosion.

(i) Explain why aluminium, a reactive metal, is resistant to corrosion.

.....

..... [1]

(ii) Suggest **two** other reasons why aluminium is suitable for making pots and pans.

.....

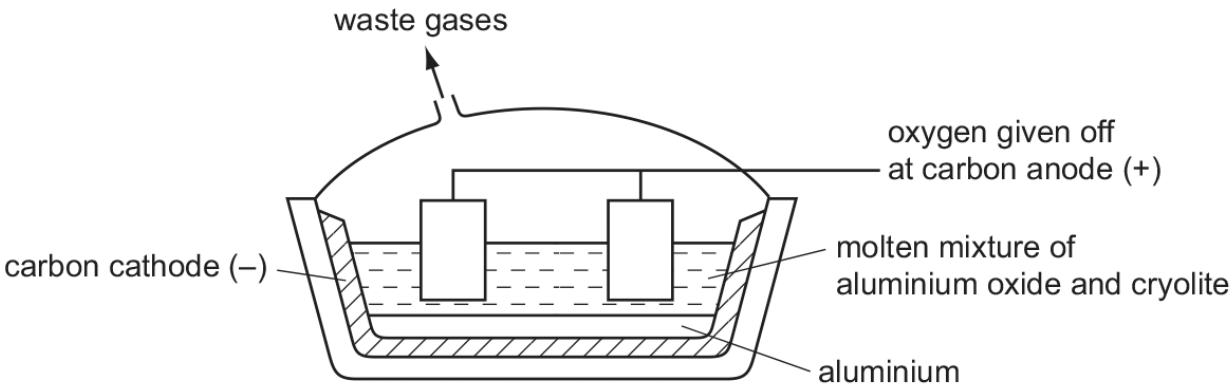
..... [2]

[Total: 19]

09. 0620_s13_qp_32 Q: 6

Aluminium is an important metal with a wide range of uses.

(a) Aluminium is obtained by the electrolysis of aluminium oxide dissolved in molten cryolite.



(i) Solid aluminium oxide is a poor conductor of electricity. It conducts either when molten or when dissolved in molten cryolite. Explain why.

.....

.....

..... [2]

(ii) Why is a solution of aluminium oxide in molten cryolite used rather than molten aluminium oxide?

..... [1]

(iii) Explain why the carbon anodes need to be replaced periodically.

..... [1]

(iv) One reason why graphite is used for the electrodes is that it is a good conductor of electricity. Give another reason.

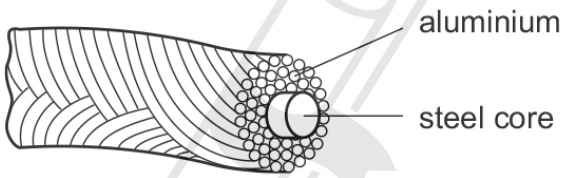
..... [1]

(b) Aluminium is used to make food containers because it resists corrosion.
Explain why it is not attacked by the acids in food.

.....

..... [2]

(c) Aluminium is used for overhead power (electricity) cables which usually have a steel core.



(i) Give **two** properties of aluminium which make it suitable for this use.

.....

..... [2]

(ii) Explain why the cables have a steel core.

.....

..... [1]

[Total: 10]

10. 0620_s13_qp_33 Q: 3

Iron from the blast furnace is impure. It contains 5% of impurities, mainly carbon, sulfur, silicon and phosphorus. Almost all of this impure iron is converted into the alloy, mild steel.

(a) (i) State a use of mild steel.

..... [1]

(ii) Name and give a use of another iron-containing alloy.

name .....

use ..... [2]

(b) The oxides of carbon and sulfur are gases. The oxides of silicon and phosphorus are not. Explain how these impurities are removed from the impure iron when it is converted into mild steel.

.....

.....

.....

.....

..... [5]

[Total: 8]

11. 0620_w12_qp_33 Q: 4

Zinc alloys have been used for over 2500 years.

(a) (i) Explain the phrase *zinc alloy*.

.....

..... [1]

(ii) Making alloys is still a major use of zinc. State **one** other large scale use of zinc.

..... [1]

(iii) Describe the bonding in a typical metal, such as zinc, and then explain why it is malleable. You may use a diagram to illustrate your answer.

.....

.....

..... [3]

(iv) Suggest why the introduction of a different atom into the structure makes the alloy less malleable than the pure metal.

.....

..... [2]

(b) Zinc metal is made by the reduction of zinc oxide. The major ore of zinc is zinc blende, ZnS. Zinc blende contains silver and lead compounds as well as zinc sulfide.
Zinc blende is converted into impure zinc oxide by heating it in air.

$$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$$

(i) Describe how zinc oxide is reduced to zinc.

..... [1]

(ii) Some of the zinc oxide is dissolved in sulfuric acid to make aqueous zinc sulfate. Write a balanced symbol equation for this reaction.

..... [2]

(iii) This impure solution of zinc sulfate contains zinc ions, silver(I) ions and lead ions. Explain why the addition of zinc powder produces pure zinc sulfate solution. Include at least one ionic equation in your explanation.

.....

.....

.....

.....

..... [4]

(iv) Describe how zinc metal can be obtained from zinc sulfate solution by electrolysis. A labelled diagram is acceptable. Include all the products of this electrolysis. The electrolysis is similar to that of copper(II) sulfate solution with inert electrodes.

[4]

[Total: 18]

01. 0620_s20_ms_43 Q: 7

(a)	breakdown of a molten / or aqueous ionic compound by the passage of electricity	2
(b)	bauxite	1
(c)(i)	it is above carbon in the reactivity series / more reactive than carbon	1

(c)(ii)	any **one** from: • aluminium oxide has high melting point / cryolite has lower melting point than aluminium oxide • using cryolite reduces costs / expensive to melt aluminium	1
(c)(iii)	oxygen	1
(c)(iv)	$Al^{3+} + 3e^- \rightarrow Al$	2
(d)	any **two** related to use as electricity cables: • ductile / malleable • conducts (electricity) • low density • protective oxide layer	2
(e)(i)	iron + water + oxygen → (hydrated) iron oxide	2
(e)(ii)	any **two** from: • act as catalysts • variable oxidation numbers • form coloured compounds / coloured ions • higher melting point • higher density • harder	2

02. 0620_w20_ms_41 Q: 2

Question	Answer	Marks
(a)	zinc blende	1
(b)(i)	$ZnO + C \rightarrow Zn + CO$ **or** $2ZnO + C \rightarrow 2Zn + CO_2$	1
(b)(ii)	chemical change: reduction (1) explanation: oxygen is lost (1)	2
(b)(iii)	aluminium is more reactive than carbon	1
(b)(iv)	electrolysis	1

Question	Answer	Marks
(c)	exists as layers (1) (alloy) contains different sized (copper) atoms (1) makes it more difficult for layers (of atoms) to slide over each slip/shift other (1)	3

03. 0620_w20_ms_42 Q: 3

Question	Answer	Marks
(a)	any **two** from: • shiny / lustrous • conduct electricity • conduct heat	2

Question	Answer	Marks
(b)	low(er) density (1) low(er) melting points (1)	2
(c)(i)	hydrogen	1
(c)(ii)	hydroxide / OH^-	1
(c)(iii)	$2Na + 2H_2O \rightarrow 2NaOH + H_2$ NaOH (as a product) (1) rest of equation (1)	2
(d)(i)	galvanising	1
(d)(ii)	prevents water or / and oxygen reaching iron	1
(d)(iii)	zinc more reactive (than iron) (1) zinc corrodes / oxidises / reacts in preference to iron (1)	2

04. 0620_w16_ms_42 Q: 6

(a)	bauxite/Alumina is dissolved in <u>molten</u> cryolite cryolite lowers the melting temperature molten aluminium forms *anode reaction*: $2O^{2-} \rightarrow O_2 + 4e^-$ *cathode reaction:* $Al^{3+} + 3e^- \rightarrow Al$	5

(b)	carbon or graphite electrode reacts with oxygen / burns (in oxygen) / combusts	2
(c)	*use 1*: manufacture of aircraft *reason 1*: low density *use 2*: food containers **OR** cooking foil *reason 2*: *Al* resistant to corrosion	4

(a)	M1 *Forming an oxide* (all) elements or (all) impurities become oxides; M2 *Gaseous oxides* carbon dioxide or sulfur (di)oxide escape / are removed as gases; M3 *Acidic oxides* silicon(IV) oxide or phosphorus(III / V) oxide react / are neutralised by calcium oxide / lime; M4 *Equation mark* any one of the following equations $S + O_2 \rightarrow SO_2$; $C + O_2 \rightarrow CO_2$ or $2C + O_2 \rightarrow 2CO$; $Si + O_2 \rightarrow SiO_2$; $4P + 5O_2 \rightarrow 2P_2O_5$ or $P_4 + 5O_2 \rightarrow 2P_2O_5$; $4P + 3O_2 \rightarrow 2P_2O_3$ or $P_4 + 3O_2 \rightarrow 2P_2O_3$; M5 *Word equation mark* any one of the following word equations calcium oxide + silicon(IV) oxide → calcium silicate; calcium oxide + phosphorus(III / V) oxide → calcium phosphate;	**5**	(All) elements or (all) impurities react with oxygen **A** M1 for any one element becoming an oxide **A** formulae / carbon monoxide **A** oxides of sulfur / carbon **I** sulfur trioxide **A** silicon (di)oxide for silicon(IV) oxide **A** phosphorus (tri/pent)oxide for phosphorus(III / V) oxide **A** multiples **I** state symbols **I** unbalanced equations **R** other combustion equations with incorrect species **A** calcium oxide + silicon(IV) oxide → slag **A** correct symbol equation for M5 but **R** other equations with incorrect species used as M5

(b)(i)	*Any **one** from:* (making) car (bodies); machinery; chains; pylons; white goods; nails; screws; as a building material; sheds / roofs; reinforcing concrete;	**1**	**A** bridges **A** tools **I** cutlery
(b)(ii)	*Any **one** from:* knives; drills; railway tracks; machine / cutting tools / hammers; razor blades; chisels;	**1**	**I** cutlery items **I** bridges
(b)(iii)	M1 atoms or cations or (positive) ions or metal ions; M2 arranged in a lattice or in layers or in rows or in a regular structure; M3 rows or layers slide over one another;	**3**	**I** (sea of) electrons **R** protons or nuclei for M1 **A** M2 non-directional forces **A** ECF on particle named in M1 for M3 **I** 'atoms' slide over one another
(b)(iv)	M1 carbon **atoms** or **particles** in structure different size (to cations); M2 so reduce moving or interrupt movement;	**2**	**R** ions and molecules for M1 **A** M2 for prevents sliding **A** M2 for 'stops' sliding

06. 0620_s14_ms_31 Q: 5

(a) M1: (zinc sulfide) heated / roasted / burnt in **air** (1)

M2: zinc oxide formed (1)

M3: zinc oxide **reduced** (1)

M4: (by adding) coke or carbon (1)

M5: Balanced equation (any one of) (1) [5]

$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$
$2ZnO + C \rightarrow 2Zn + CO_2$
$ZnO + C \rightarrow Zn + CO$
$ZnO + CO \rightarrow Zn + CO_2$

(b) Any **two** from: [2]

- (making) brass **or** alloys (1)
- galvanising (1)
- sacrificial protection (1)
- batteries (1)

[Total: 7]

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07. 0620_s14_ms_33 Q: 4

(a) **(i)** heat limestone / calcium carbonate (1)
fractional distillation (1)
liquid air (1) [3]

(ii) any **two** of the oxides, C, S, P and Si, mentioned (1)
carbon dioxide and sulfur dioxide escape / are gases (1)

phosphorus oxide **or** silicon(IV) oxide react with calcium oxide /
phosphorus oxide **or** silicon(IV) oxide are acidic and calcium oxide is basic (1)

to form a slag **or** calcium silicate **or** calcium phosphate (1)

must have correct equation for one of the above reactions (1) [5]

(b) **(i)** lattice / rows / regular arrangement of cations / positive ions / Fe^{2+} (1)
mobile / free / delocalised / sea of electrons (1) [2]

(ii) the rows of ions / ions can move past each other (1)
without the metal breaking / bonds are not directional / not rigid (1) [2]

(iii) carbon particles / atoms different size (1)
prevents movement of rows, etc. (1) [2]

[Total: 14]

(a) $Al^{3+} + 3e^- \rightarrow Al$ [2]
species (1) balancing (1)

(b) **(i)** $AlCl_3 + 3Na \rightarrow 3NaCl + Al$ [2]
species (1) balancing (1)

(ii) M1 electrolysis [1]

M2 molten sodium chloride [1]
or
M1 Add named more reactive metal (e.g. K)
M2 Molten sodium chloride

(c) **(i)** bauxite [1]

(ii) M1 aluminium oxide / amphoteric oxide dissolves OR iron(III) oxide / basic oxide does not [1]

M2 Filter **COND** on M1 [1]

(iii) Any **two** from:
Lowers (working) temperature or lowers mpt (of mixture)
increases conductivity
reduces cost OR energy need [2]

(iv) M1 = Any one correct equation.

M2 Oxygen mark
Oxygen comes from oxide ions
or $2O^{2-} \rightarrow O_2 + 4e$

M3 Carbon dioxide mark
Anode reacts with oxygen / burns to form CO_2
or $C + O_2 \rightarrow CO_2$

M4 Carbon monoxide mark
Anode reacts with limited oxygen / incompletely burns to form carbon monoxide
or $2C + O_2 \rightarrow 2CO$
or CO_2 reacts with the anode to form carbon monoxide
or $CO_2 + C \rightarrow 2CO$

M5 Fluorine mark
Fluorine comes from cryolite or fluoride ions
or $2F^- \rightarrow F_2 + 2e^-$ [5]

(d) **(i)** Has an impervious **or** non-porous **or** passive **or** unreactive **or** protective oxide layer [1]

(ii) Any **two** from:
good conductor of heat
high melting point
Unreactive towards foods [2]

09. 0620_s13_ms_32 Q: 6

(a) (i) ions cannot move / no free ions in solid state [1]
ions can move / free ions in liquid state [1]
note: ions can <u>only</u> move in liquid state = 2

(ii) reduce melting point / reduce energy costs / better conductor when dissolved in cryolite [1]

(iii) burns in oxygen / reacts with oxygen / oxidised by oxygen / forms carbon dioxide / forms carbon monoxide [1]

(iv) high melting point / inert / unreactive [1]

(b) protective / unreactive / resists / prevents corrosion / non-porous (layer) [1]

of (aluminium) oxide [1]

(c) (i) good conductor (of electricity) [1]
low density / light / lightweight [1]

(ii) steel core (increased) strength / prevent sagging / to increase separation of pylons / support [1]

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10. 0620_s13_ms_33 Q: 3

(a) (i) cars, ships, bridges, construction, white goods, screws, nails, roofing, fencing, etc. [1]

(ii) e.g. stainless steel [1]
cooking utensils, surgical equipment, sinks or main use [1]

(b) blow in oxygen **NOT** air [1]
carbon dioxide <u>and</u> sulfur dioxide (escape as gases) [1]
COND on reaction with air / oxygen
add calcium oxide / quicklime [1]
ALLOW calcium carbonate, limestone
phosphorus oxide **or** silicon oxide (are acidic)
reacts (with calcium oxide / $CaCO_3$) [1]
to form slag / calcium silicate [1]

(a) (i) zinc mixed with an element(s) or metal(s) or non-metal; [1]

(ii) galvanising / baths / coating steel (i.e. description of galvanising) / roofing / sacrificial protection / protection from rusting / electroplating / zinc plating / batteries; [1]

(iii) (lattice) positive ions / cations / metal ions / sea of electrons / delocalised or free or mobile or moving electrons; [1]
attraction between positive ions and electrons; [1]
the layers (of ions) or particles can slide or slip or shift past each other; [1]

(iv) different atom / ion / particle of different size; [1]
prevents (layers / atoms / ions / particles / molecules) moving / slipping / sliding / shifting; [1]

(b) (i) heat with carbon or coke or carbon monoxide; [1]

(ii) $ZnO + H_2SO_4 \rightarrow ZnSO_4 + H_2O$ [2]
[1] for correct reactants [1]for correct products

(iii) zinc (**not:** ions) more reactive than silver and lead; [1]
zinc displaces both metals / silver **and** lead produced / ions become atoms / zinc reduces silver ions and lead ions; [1]
(silver and lead) can be removed by filtering / centrifugation / decanting; [1]

an ionic equation; i.e.
$Zn + 2\ Ag^+ \rightarrow Zn^{2+} + 2Ag$ or $Zn + Pb^{2+} \rightarrow Zn^{2+} + Pb$ [1]
allow: any two correct half equations

(iv) cathode labelled carbon / zinc / platinum; [1]
zinc deposited at cathode; [1]
oxygen formed (at anode); [1]
(electrolyte becomes) sulfuric acid / remaining solution contains H^+ and SO_4^{2-}; [1]

[Total: 18]