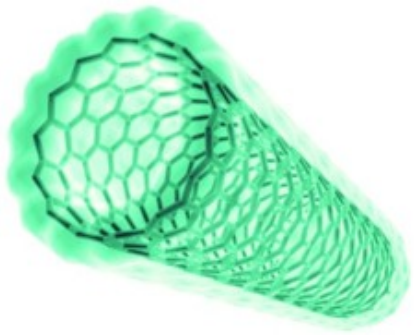
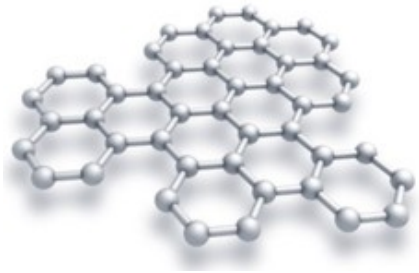
Q1. Carbon atoms are used to make nanotubes.



Carbon atoms in a nanotube are bonded like a single layer of graphite.

The figure below shows the structure of a single layer of graphite.



(a) Suggest why carbon nanotubes are used as lubricants.

.....

.....

.....

.....

(2)

(b) Explain why graphite can conduct electricity.

.....

.....

.....

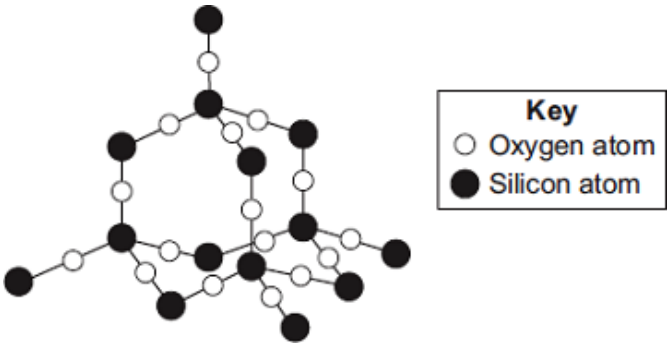
.....

(2)
(Total 4 marks)

Q2. Silicon dioxide is used as a lining for furnaces.

Furnaces can be used to melt iron for recycling.

The diagram shows a small part of the structure of silicon dioxide.



Explain why silicon dioxide is a suitable material for lining furnaces.

.....

.....

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.....

(Total 4 marks)

Q3. Oil rigs are used to drill for crude oil.

(a) Drill heads are made from steel. Steel is an alloy.

Explain why alloys are harder than pure metals.

.....

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.....

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.....

.....

(3)

(b) Drill heads also contain diamonds.

Describe, as fully as you can, the structure and bonding in diamond.

.....

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(4)

(c) Polymers are produced from crude oil.

Describe the structure and bonding in a thermosoftening polymer and explain why thermosoftening polymers melt when heated.

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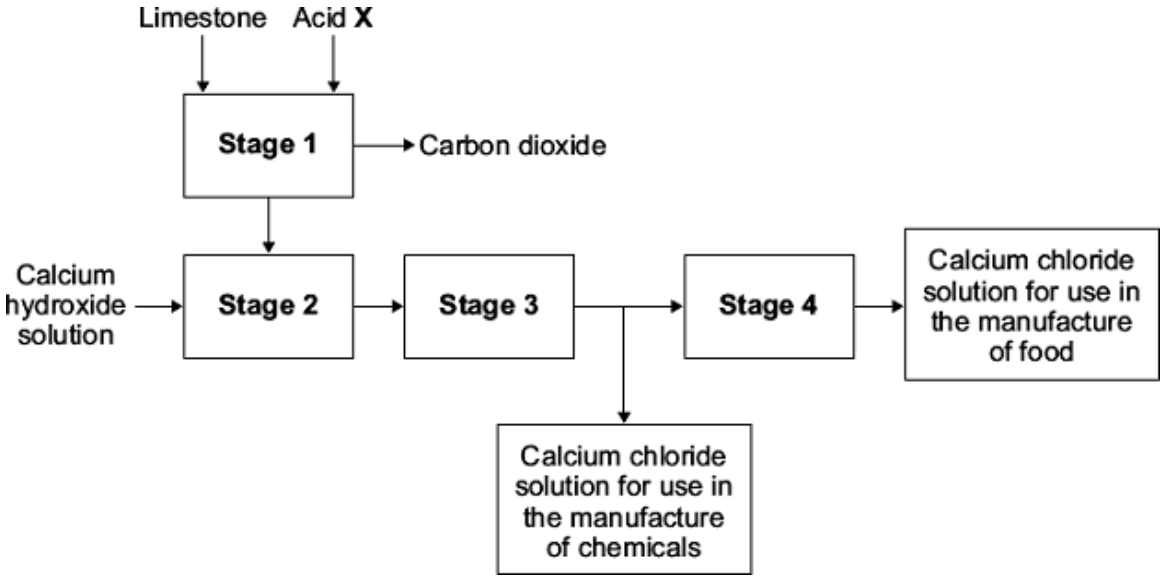
(4)
(Total 11 marks)

Q4. (a) Calcium chloride is made from limestone. The limestone used contains mainly calcium carbonate and a small amount of magnesium carbonate.



(i) In **stage 1** calcium carbonate reacts with acid **X** to form calcium chloride.

Name acid **X**.

.....

(1)

(ii) **Stage 1** produces a concentrated solution of calcium chloride.
The solution also contains magnesium chloride.

Calcium hydroxide solution is added to remove the magnesium chloride:

$$MgCl_2(aq) + Ca(OH)_2(aq) \rightarrow Mg(OH)_2(s) + CaCl_2(aq)$$

This is an example of a *precipitation* reaction.

What is the meaning of the term *precipitation* reaction?

.....

.....

(1)

(iii) The magnesium hydroxide can be separated from the calcium chloride solution.

State how.

.....

.....

(1)

(iv) Suggest why **stage 4** is needed.

.....

.....

(1)

(v) Name a method that can be used to change calcium chloride solution into solid calcium chloride.

.....

(1)

(b) Calcium chloride can also be made by reacting calcium with chlorine.

Calcium chloride is an ionic compound. It contains calcium ions (Ca^{2+}).

(i) Complete the equation for the formation of calcium ions.

$$Ca \rightarrow Ca^{2+} + ...$$

(1)

(ii) Why can the formation of calcium ions from calcium atoms be described as oxidation?

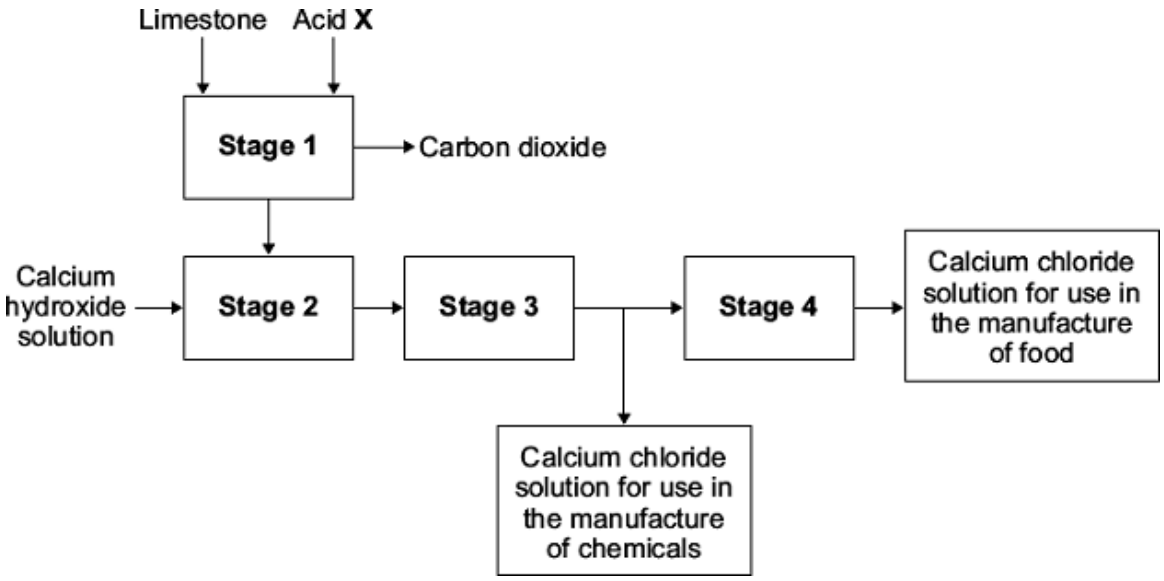
.....

.....

(1)

(Total 7 marks)

Q5. (a) Calcium chloride is made from limestone. The limestone used contains mainly calcium carbonate and a small amount of magnesium carbonate.



(i) In **stage 1** calcium carbonate reacts with acid **X** to form calcium chloride.

Name acid **X**.

.....

(1)

(ii) **Stage 1** produces a concentrated solution of calcium chloride.
The solution also contains magnesium chloride.

Calcium hydroxide solution is added to remove the magnesium chloride:

$$MgCl_2(aq) + Ca(OH)_2(aq) \rightarrow Mg(OH)_2(s) + CaCl_2(aq)$$

This is an example of a *precipitation* reaction.

What is the meaning of the term *precipitation* reaction?

.....

.....

(1)

(iii) The magnesium hydroxide can be separated from the calcium chloride solution.

State how.

.....

.....

(1)

(iv) Suggest why **stage 4** is needed.

.....

.....

(1)

(v) Name a method that can be used to change calcium chloride solution into solid calcium chloride.

.....

(1)

(b) Calcium chloride can also be made by reacting calcium with chlorine.

Calcium chloride is an ionic compound. It contains calcium ions (Ca^{2+}).

(i) Complete the equation for the formation of calcium ions.

$Ca \rightarrow Ca^{2+} + ...$

(1)

(ii) Why can the formation of calcium ions from calcium atoms be described as oxidation?

.....

.....

(1)
(Total 7 marks)

Q6. Spacecraft have been to the planets Venus and Mars. The spacecraft have sent back information about the atmosphere of each planet.

© Tristan3D/Shutterstock

(a) The main gas in the atmosphere of Mars is carbon dioxide.

Explain why, in terms of structure, carbon dioxide is a gas, even at low temperatures.

.....

.....

.....

.....

.....

.....

.....

.....

(3)

(b) Gas chromatography linked to a mass spectrometer (GC-MS) is used to identify substances found on Mars.

(i) What is the purpose of gas chromatography?

.....

.....

(1)

(ii) What information do the molecular ion peaks from the mass spectrometer give about the substances?

.....

(1)

(c) The atmosphere on Venus contains droplets of sulfuric acid solution.

(i) Suggest a pH value for sulfuric acid solution.

pH = ...

(1)

(ii) Name the ion which makes sulfuric acid solution acidic.

.....

(1)

(d) The atmosphere of Venus contains the isotopes $^{2}_{1}H$ and $^{1}_{1}H$

Describe the similarities and the differences in the isotopes $^{2}_{1}H$ and $^{1}_{1}H$

You should refer to the sub-atomic particles in each isotope.

.....

.....

.....

.....

.....

.....

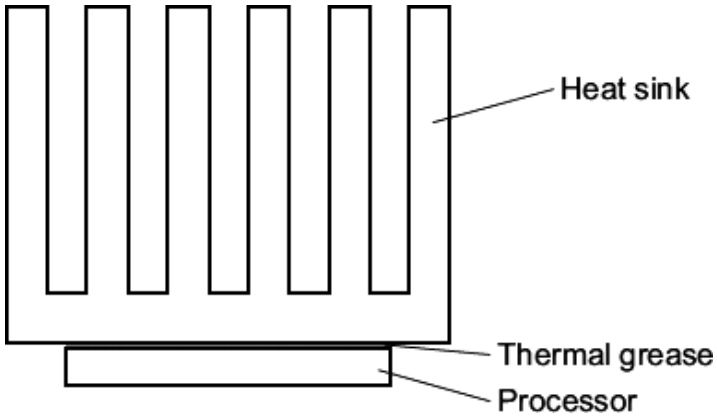
.....

.....

(3)

(Total 10 marks)

Q7. The diagram shows how a heat sink is placed on top of a processor in a computer.
The heat sink is a large piece of metal which conducts heat away from the processor.
If the processor gets too hot it may be damaged.



(a) (i) Describe the structure of a metal.

.....

.....

.....

.....

.....

.....

.....

.....

(3)

(ii) Why are metals very good conductors of heat?

.....

.....

(1)

(b) When viewed under a microscope, it can be seen that the surfaces of the processor and the heat sink that are in contact are not flat.
There are lots of tiny gaps between the two surfaces.
The gaps contain air, which does not conduct heat very well.
Thermal grease is used to fill the gaps between the processor and the heat sink to improve the transfer of heat from the processor to the heat sink.

One type of thermal grease contains nanosized particles of silver.
The manufacturer claims that the nanosized particles help to transfer heat better than normal sized particles.

(i) How are nanosized particles different from normal sized particles?

.....

.....

(1)

(ii) Suggest **one** reason why nanosized particles of silver might help to transfer heat better than normal sized particles.

.....

.....

(1)
(Total 6 marks)

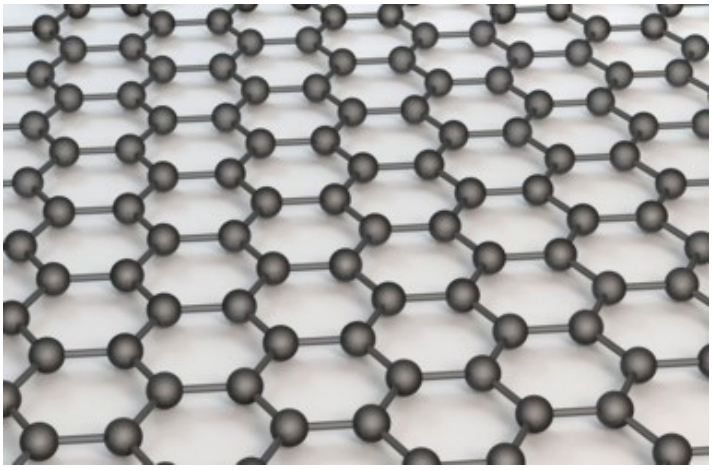
Q8. Scientists have recently developed a method to produce large sheets of a substance called graphene.
Graphene is made from carbon and is a single layer of graphite just one atom thick.

The properties of graphene include:

- it conducts electricity
- it is transparent since it is only one atom thick
- it is strong and durable.

These properties make it suitable to overlay a monitor screen to make it a touchscreen.

The photograph below shows the structure of graphene.



Photographs supplied by iStockphoto/Thinkstock

Use your knowledge of the bonding in graphite and the photograph of the structure to help you to explain, as fully as you can:

(a) (i) why graphene is strong;

.....

.....

.....

.....

.....

.....

(3)

(ii) why graphene conducts electricity.

.....

.....

.....

.....

.....

(2)

(b) Suggest why a sheet of graphite which has a large number of carbon layers would not be suitable for the touchscreen.

.....

.....

(1)

(Total 6 marks)

Q9. Read the information in the box.

Flash powder is used to produce special effects at pop concerts.

Flash powder contains aluminium. The powder burns with a bright white flame and gives out lots of heat and light. It also produces white smoke.

The flash powder is placed on stage in a special container. At the bottom of the container there is a thin piece of wire. When the flash is needed, electricity is passed through the wire. The wire gets hot and starts the aluminium burning.

By russelljsmith [CC BY 2.0], via Flickr

(a) When aluminium burns the reaction is *exothermic*.

What is the meaning of *exothermic*?

.....

.....

(1)

(b) The hot wire provides energy to start the aluminium burning.

What is the name given to the heat energy needed to start a chemical reaction?

..... energy

(1)

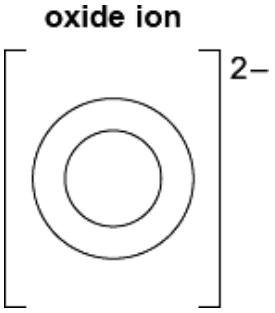
(c) The white smoke produced is aluminium oxide.

Aluminium oxide contains aluminium ions (Al^{3+}) and oxide ions (O^{2-}).

(i) Complete the diagram to show the electronic structure of an oxide ion.

The atomic number of oxygen = 8

Use crosses (x) to represent the electrons.



(1)

(ii) The bonding in aluminium oxide is ionic.

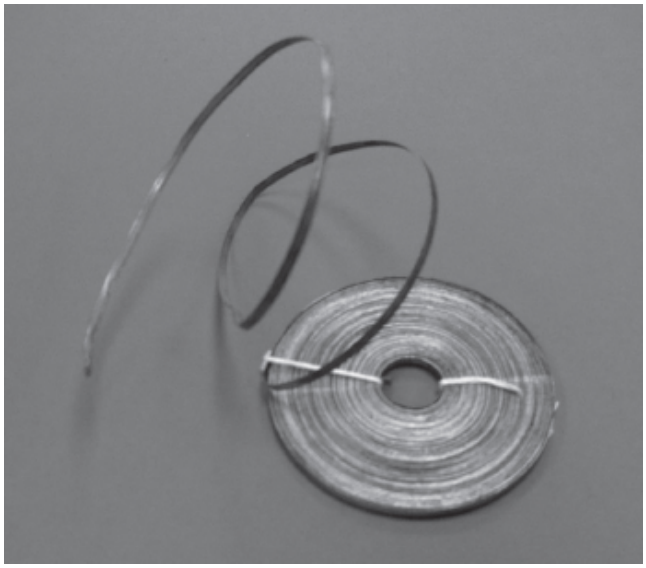
What causes the aluminium ions and oxide ions to be held together strongly?

.....

.....

(1)
(Total 4 marks)

Q10. (a) Magnesium metal is shaped to make magnesium ribbon.



Explain why metals can be shaped.

.....

.....

.....

.....

.....

(2)

(b) Magnesium sulfate is a salt of magnesium.

It can be prepared by the reaction of magnesium metal with an acid. The equation for the reaction of magnesium with this acid is:

$$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$$

(i) Name the acid used to make magnesium sulfate.

..... acid

(1)

(ii) Use the equation to help you to describe what you would **observe** when magnesium reacts with the acid.

.....

.....

.....

.....

.....

(2)

(iii) The magnesium sulfate is in solution.

How could you obtain solid magnesium sulfate from this solution?

.....

.....

(1)

(Total 6 marks)

M1. (a) nanotubes can slide (over each other)

allow nanotubes can roll (over each other)

1

because no (covalent) bonds between the nanotubes

*accept weak forces between the nanotubes **or** weak intermolecular forces*

allow layers for nanotubes throughout

1

(b) delocalised electrons

accept free electrons

1

so (delocalised) electrons can move <u>through the graphite</u>

accept so (delocalised) electrons can carry charge <u>through the graphite</u>

1

[4]

M2. high melting point

*reference to incorrect bonding **or** incorrect particles **or** incorrect structure = max **3***

accept will not melt (at high temperatures)
ignore withstand high temperatures

1

because a lot of energy needed to break bonds

1

because it is covalent **or** has strong bonds

accept bonds are hard to break

1

and because it is a giant structure **or** a macromolecule **or** a lattice

ignore many bonds

1

[4]

M3. (a) because atoms / ions / particles in alloy are different (sizes)

*do **not** allow reference to molecules*

ignore reference to compounds

1

so layers distorted

(and layers / atoms / ions / particles) don't slide **or** slide less easily

accept all marking points in a suitably labelled or annotated diagram

1

*if no other mark awarded accept an alloy is a mixture **or** contains different metals / elements for **1** mark*

1

(b) giant structure **or** lattice **or** macromolecule

*max **3** marks if incorrect bonding*

1

strong bonds (between carbon / atoms)

1

covalent (bonds)

1

each carbon / atom forms 4 bonds

accept tetrahedral

*if no other marks awarded, allow carbon (atoms) for **1** mark*

1

(c) *reference to incorrect bonding = max **3***
*reference to 'weak covalent bonds' = max **2***
allow correctly drawn diagram for first two marking points eg. (tangled) lines with no cross-links

chains **or** large molecules

ignore layers

1

with intermolecular forces **or** forces between chains

allow bonds for forces accept no cross-links

1

that are weak

must relate to 2 nd marking point

1

and are easily overcome/ broken (when heated)

accept molecules / chains can flow / move

1

[11]

M4. (a) (i) hydrochloric (acid) / HCl

allow phonetic spelling
ignore incorrect formula
ignore state symbols

1

(ii) idea of a solid / insoluble substance being formed (from solutions)

accept solid / insoluble product
ignore cloudy
*do **not** accept evaporation*

1

(iii) filtration / filter

accept decanting / centrifugation
ignore evaporate if after filtering

1

(iv) idea of making safe (to eat)

*allow remove harmful substances / organisms **or** sterilisation*

or
idea of purification
or
idea of neutralisation

1

(v) crystallisation

accept evaporation / heating / boiling
allow cooling
*do **not** allow freezing / solidifying*

1

(b) (i) $2e^-$

accept $e^- + e^-$
ignore working out

1

(ii) electron(s) are lost (from calcium atoms)

ignore numbers if given
*do **not** accept any reference to oxygen*

1

[7]

M5. (a) (i) hydrochloric (acid) / HCl

allow phonetic spelling
ignore incorrect formula
ignore state symbols

1

(ii) idea of a solid / insoluble substance being formed (from solutions)

accept solid / insoluble product
ignore cloudy
*do **not** accept evaporation*

1

(iii) filtration / filter

accept decanting / centrifugation
ignore evaporate if after filtering

1

(iv) idea of making safe (to eat)

*allow remove harmful substances / organisms **or** sterilisation*

or
idea of purification
or
idea of neutralisation

1

(v) crystallisation

accept evaporation / heating / boiling

allow cooling

*do **not** allow freezing / solidifying*

1

(b) (i) $2e^-$

accept $e^- + e^-$

ignore working out

1

(ii) electron(s) are lost (from calcium atoms)

ignore numbers if given

*do **not** accept any reference to oxygen*

1

[7]

M6. (a) has simple / small molecules

accept molecular covalent

1

the intermolecular forces / intermolecular bonds (are weak)

*do **not** accept weak covalent bonds **or** reference to incorrect bonding*

1

only need a small amount of energy to be overcome

accept only need a small amount of energy to separate the molecules

*if no other mark awarded, allow it has a low boiling point for **1** mark*

1

(b) (i) to separate

1

(ii) (relative) molecular mass

allow M_r / (R)MM / relative mass / mass of molecule / (R)FM

1

(c) (i) any pH value from 0 to 6.9

1

(ii) hydrogen

allow H^+

ignore H / H_2 / H^-

1

(d) any **three** from:

- same number of protons
  accept same atomic number
  numbers if given must be correct

- ^{2}H has one neutron

- ^{1}H has no neutrons
  *accept different mass number **or** different number of neutrons for **1** mark*
  ignore relative atomic mass

- same number of electrons
  numbers if given must be correct

3

[10]

M7. (a) (i) *mention of molecules / intermolecular / ionic / covalent* = ***max 2***

atoms / positive ions

1

any **two** from:

- (atoms / positive ions) in regular pattern / lattice / layer / giant structure (or diagram)

- delocalised electrons
  accept electrons move within / through the structure
  allow free (moving) electrons
  allow sea of electrons

- (atoms / positive ions) held together by strong / electrostatic attractions
  allow strong (metallic) bonds

2

(ii) delocalised electrons
accept electrons move within / through the structure
allow free electrons

1

(b) (i) smaller / very small
accept converse
accept 1 - 100 nanometres in size
accept a few hundred atoms
*accept larger surface area **or***
large surface area for their size

1

(ii) nanoparticles / more can fit into (tiny) gaps

allow nanosize particles have large(r) surface area

1

[6]

M8. (a) (i) *ionic / molecules / metallic / (inter)molecular = max **2***

because graphene / it has a giant structure / lattice / macromolecular

accept <u>all</u> / <u>every</u> / <u>each</u> atom is <u>bonded to</u> 3 other atoms

1

because graphene / it has covalent bonds / is covalent

1

because in graphene / the bonds are strong **or**
a lot of energy needed / hard to break the bonds

1

(ii) there are delocalised / free electrons

1

because one (delocalised / free) electron <u>per atom</u> linked to first marking point

accept because three <u>electrons per atom</u> used (in bonding)

accept because one electron <u>per atom</u> not used (in bonding)

1

(b) opaque (owtte)

eg could not see through them

or layers slide
or layers not aligned

ignore thick

1

[6]

M9. (a) gives out heat / energy

allow more energy given out in making bonds than is used in breaking bonds

or

energy / heat transferred to surroundings

ignore light

1

(b) activation

allow phonetic spelling

1

(c) (i) 2 crosses on inner circle **and**

8 crosses on outer circle

accepts dots / e / – for electrons

1

(ii) opposite charges (attract)

allow electrostatic forces (attract)

*do **not** accept intermolecular attraction / shared electrons*

1

[4]

M10. (a) • made of layers / rows (atoms / ions / particles)

ignore free / delocalised electrons

1

• which can slide / slip (over each other)

*reference to incorrect particles / covalency / intermolecular forces = max **1***

or

particles / ions / atoms can slide over each other

ignore malleable / ductile / weak bonds

1

(b) (i) sulfuric

accept sulphuric

ignore formula

ignore hydrogen sulfate

1

(ii) any **two** from:

list principle applies for incorrect observations

• (hydrogen) gas produced (or any indication of a gas such as bubbles etc.)

ignore just hydrogen produced

ignore cloudiness / colour changes

• magnesium / solid disappears / goes into solution

accept magnesium / magnesium sulfate / solid / it dissolves

accept forms a liquid / solution

• gets hot

allow exothermic

ignore floats

2

(iii) crystallisation

accept detailed answers such as: evaporate to half volume and then allow the solution to crystallise.

or

evaporation / heating / boiling / cooling

ignore any references to filter

1

[6]