M1.(a) (i) giant lattice

allow each carbon atom is joined to three others

1

atoms in graphene are covalently bonded

*max. **2** marks if any reference to wrong type of bonding*

1

and covalent bonds are strong **or** need a lot of energy to be broken

allow difficult to break

1

(ii) because graphene has delocalised electrons

allow each carbon atom has one free electron

1

which can move <u>throughout the structure</u>

*do **not** accept just electrons can move.*

1

(b) because there are weak forces between molecules

allow no <u>bonds</u> between the layers

1

so layers / molecules can slip / slide.

1

[7]

M2.(a) (i) any **two** from:

ignore any conclusion drawn referring to data below 7.5 nm or above 20 nm

- *100% of (type 1 and type 2) bacteria are killed with a particle size of 7.5 to 8.5 nm*

  accept nanoparticles in the range of 7.5 to 8.5 nm are most effective at killing (type 1 and type 2) bacteria
- *as the size increases (beyond 8.5 nm), nanoparticles are less effective at killing (type 1 and type 2) bacteria*
- *type 1 shows a linear relationship **or** type 2 is non-linear*
- type 1 bacteria more susceptible than type 2 (at all sizes of nanoparticles shown on the graph)

  allow type 2 bacteria are harder to kill

2

(ii) (yes) because you *could confirm the pattern that has been observed*

allow would reduce the effect of anomalous points / random errors

allow would give better line of best fit

ignore references to reliability / precision / accuracy / reproducibility / repeatability / validity

or

(no) because trend / *conclusion* is already clear

1

(b) magnesium loses electron(s)

1

oxygen gains electron(s)

1

<u>two</u> electrons (per atom)

1

gives full outer shells (of electrons) **or** *eight electrons in highest energy level*

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

1

or

(electrostatic) attraction between ions **or** forms ionic bonds

accept noble gas structure

[7]

M3. (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) small<u>er</u> / <u>very</u> small
accept converse
accept 1 - 100 nanometres in size
accept a few hundred atoms
*accept larg<u>er</u> 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]

M4. (a) because calcium is +2 and hydroxide is –1

accept to <u>balance</u> the charges

or

to make the compound neutral (in terms of charges)

allow calcium needs to lose 2 electrons and hydroxide needs to gain one electron

1

(b) particles of size 1-100 nm

allow clear comparison to 'normal' size particles

or particles with a few hundred atoms / ions

or particles with a high surface area (to volume ratio)

or as different properties to 'normal' size particles of the same substance

1

(c) $\mathbf{M}_r$ CaO = 56

and

$\mathbf{M}_r$ $Ca(OH)_2$ = 74

1

2/56 (x74) **or** 0.036 (x74)

or

allow ecf from step 1

74/56 (x2) **or** 1.3(214…) (x2)

1

2.6(428…) in range 2.6 to 2.96

*correct answer with or without working gains **3** marks*

allow ecf carried through from step 1

ignore final rounding to 3

1

[5]

M5. (a) any **four** from:

*max **3** marks if any reference made to covalent / ionic bonding / molecules or intermolecular forces **or** graphite / diamond **or** forces of attraction between electrons and then ignore throughout*

- giant structure / lattice
  ignore layers
- positive ions
- sea of electrons **or** delocalised / free electrons
  ignore electrons can move
- awareness of outer shell / highest energy level electrons are involved
- (electrostatic) attractions / bonds between electrons and positive ions
- bonds / attractions (between atoms/ ions) are strong
  allow hard to break for strong
  ignore forces unqualified
- a lot of energy / heat is needed to break these bonds / attractions
  ignore high temperature

4

(b) (i) that they are very small

accept tiny / really small / a lot smaller / any indication of very small

eg microscopic, smaller than the eye can see

or

1–100 nanometres **or** a few (hundred) atoms

ignore incorrect numerical values if very small is given

1

(ii) any **2** from:

- one (non-bonded) electron from each atom
- delocalised / free electrons
  allow sea of electrons
  ignore electrons can move

- electron carry / form / pass current / charge
  ignore carry electricity

2

[7]

M6. (a) nanoparticles / they are small(er)

accept 1–100 nm or a few atoms in size

1

so can easily pass through pores / skin / cell / membranes / arteries / veins / capillaries / into blood stream owtte

must be a comparative statement

can be inferred from small<u>er</u> particles

allow absorbed for pass through

1

(b) any **one** from:

- may be toxic (to cells / specific cells)

  *allow may harm / damage / kill cells / organs / tissues **or** may cause cancer*

- to ensure safety **or** reduce risk **or** risk of litigation

  allow may cause allergies / side effects

  ignore harmful / dangerous unqualified eg harmful to body / people

- nanoparticles may have different properties

- to see if they pass into the body

1

(c) any **two** sensible ideas from eg:

- testing is expensive **or** testing costs money

  allow it costs money

  ignore litigation

- testing is time consuming

- don't see any reason to test since normal sized particles (of titanium oxide) do not cause harm

  *accept normal sun cream does **not** cause harm owtte*

- don't want to risk not producing a popular product (owtte)

  *eg if unsafe will have to stop production **or** have to remove product if toxic*

- testing process / unfavourable results might cause alarm / reduce sales / reduce profit (less money)

- do not want to be seen doing animal testing

2

[5]