Mark schemes

## Q1.

(a) they form ions with different charges

**1**

they have high melting points

**1**

(b) the (grey) crystals are silver

**1**

the copper ions (produced) are blue

*allow the copper nitrate / compound (produced) is blue*

**1**

(because) copper displaces silver

**1**

(c) **Level 2:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.

**3−4**

**Level 1**: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

**1−2**

**No relevant content**

**0**

**Indicative content**

**Key steps**

- add the metals to (dilute) hydrochloric acid
- measure temperature change
  **or**
  compare rate of bubbling
  **or**
  compare colour of resulting solution

for copper:

- no reaction
- shown by no temperature change
  **or**
  shown by no bubbles

for magnesium and iron:

- magnesium increases in temperature more than iron
  **or**
  magnesium bubbles faster than iron
  **or**
  magnesium forms a colourless solution and iron forms a coloured solution

**Control variables**

- same concentration / volume of hydrochloric acid
- same mass / moles of metal
- same particle size of metal
- same temperature (of acid if comparing rate of bubbling)

(d)

$$\frac{(203 \times 30) + (205 \times 70)}{100}$$

or

$$\frac{6090 + 14\,350}{100}$$

**1**

= 204.4

*ignore units*

**1**

**[11]**

## Q2.

(a) contain delocalised electrons

*allow contain free electrons*

**1**

(so) electrons can move through the structure / nanotube

*allow (so) electrons can carry charge through the structure / nanotube*
*ignore throughout for through*
*ignore current / electricity for charge*

**1**

(b) **Level 2:** Some logically linked reasons are given. There may also be a simple judgement.

**3–4**

**Level 1:** Relevant points are made. They are not logically linked.

**1–2**

No relevant content

**0**

**Indicative content**

- wood is the least dense so lightest to use
- aluminium is the most dense so will make the racket too heavy

- carbon nanotube is the strongest so least likely to break
- wood / aluminium are too weak so the racket will break more easily

- carbon nanotube is the stiffest so least likely to bend out of shape
- wood / aluminium are not very stiff so could bend out of shape

- justified conclusion

(c)

*an answer of 4.0 x $10^4$ ($nm^2$) scores **3** marks*
*an answer of 40344 ($nm^2$) scores **2** marks*

($82^2$ =) 6724 ($nm^2$) **1**

(6 x 6724 =) 40344 ($nm^2$)

*allow 40344 ($nm^2$) correctly rounded to any number of significant figures*
*allow correct calculation using incorrectly calculated value of area of one face from step1*

**1**

= 4.0 x $10^4$ ($nm^2$)

*allow 4.0344 x $10^4$ ($nm^2$) correctly rounded to 1 or more significant figures*
*allow a correctly calculated and rounded conversion to standard form of an incorrect calculation of surface area*

**1**

(d)

*allow converse statements about fine particles*

any **one** from:

- less can be used (for the same effect)
  *ignore nanoparticles are smaller*
- greater surface area (to volume ratio)

**1**

**[10]**

## Q3.

(a) fuel **1**

(b) propene **1**

(c) (percentage yield =)

$\frac{380}{400} \times 100$ **1**

= 95 (%) **1**

(d) some ethanol changes back into ethene and steam **1**

some ethanol escapes from the apparatus **1**

(e) $C_2H_5OH$ + **3** $O_2$ → $3\ H_2O + 2\ CO_2$

*allow multiples*

**1**

(f) (advantages)

(fermentation) low energy usage 1

(fermentation) uses renewable raw materials 1

(disadvantages)

(fermentation) produces impure ethanol 1

(fermentation) slow rate of reaction 1

**[11]**

## Q4.

(a) water vapour

*allow steam*

*allow gaseous water* 1

(b) 75 ($cm^3$) 1

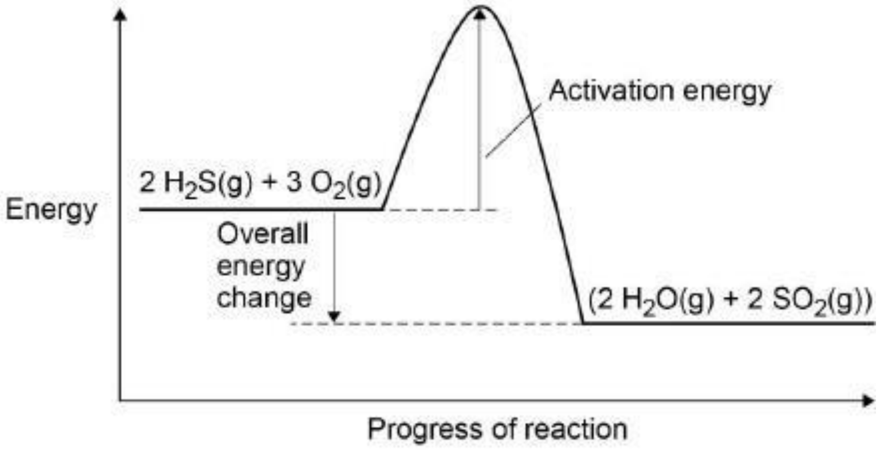
(c) product level below reactants

*ignore labelling of products* 1

activation energy drawn and labelled 1

overall energy change drawn and labelled

*if endothermic profile drawn allow corresponding overall energy change*




scores **3** marks 1

(d) (bonds broken = 4(364) + 3(498) =) 2950 1

(bonds formed = 2950 + 1034 =) 3984

*allow correct use of incorrectly calculated values of bonds broken*

1

4**X** + 4(464) = 3984

*allow correct use of incorrectly calculated values of bonds formed*

1

4**X** = **(**3984 – 1856 =) 2128

1

**X** = 532 (kJ/mol)

1

**alternative approach:**

(bonds broken = 4(364) + 3(498) =) 2950 (1)

(bonds formed = 4(464) + 4**X** =) 1856 + 4**X** (1)

(1856 + 4**X**) – 2950 = 1034 (1)

*allow correct use of incorrectly calculated values of bonds broken and/or bonds formed*

4**X** = (1034 + 2950 – 1856 =) 2128 (1)

**X** = 532 (kJ/mol) (1)

**[10]**

## Q5.

(a) the activation energy should be from the reactants (line to the peak)

*ignore description of where the activation energy is on the diagram*

1

the products (line) should be below the reactants (line)
**or**
the products should have less energy than the reactants

*allow the product (line) is above the reactants (line)*

*allow the products have more energy than the reactants allow the profile shows an endothermic reaction*

*ignore the arrow for the overall energy change should point downwards*

1

(b) any **two** from: (hydrogen fuel cells)

*allow converse arguments for a rechargeable cell*

- no toxic chemicals to dispose of at the end of the cell's life
- take less time to refuel (than to recharge rechargeable cells)
- travel further before refuelling (than before recharging rechargeable

cells)

*allow has a greater range*

- no loss of efficiency (over time)

  *allow does not lose capacity / range in cold weather 2*

**2**

(c) any **one** from:

*allow multiples*

- $H_2 \longrightarrow 2\ H^+ + 2\ e^-$

  *allow* $H_2 - 2\ e^- \longrightarrow 2\ H^+$

- $O_2 + 4\ H^+ + 4\ e^- \longrightarrow 2\ H_2O$

  *allow* $H_2 + 2\ OH^- - 2\ e^- \longrightarrow 2\ H_2O$

- $H_2 + 2\ OH^- \longrightarrow 2\ H_2O + 2\ e^-$

- $O_2 + 2\ H_2O + 4\ e^- \longrightarrow 4\ OH^-$

**1**

(d) any **two** from:

- hydrogen is not shown as $H_2$ / molecules
- particles are shown as spheres
- particles are shown as solid
- does not show the (weak) forces (between particles)
- does not show the movement / speed (of particles)
- is only two-dimensional

**2**

(e) any **one** from:

- under (higher) pressure

  *allow increase concentration*
- cool

  *allow condense*
- absorb / adsorb in a solid

  *allow store as a liquid / solid*

  *allow develop more efficient engines*

**1**

(f) (58 MJ =) 58 000 kJ

**or**

(290 kJ =) 0.290 MJ

*allow (58 MJ =) 58 000 000 J*

***and***

*(290 kJ =) 290 000 J*

**1**

(moles = $\frac{58000}{290}$ **or** $\frac{58}{0.290}$

*allow correct use of an incorrectly converted or unconverted value of energy*

**1**

(volume =) 200 × 24

*allow correct use of an incorrectly calculated number of moles of hydrogen*

1

= 4800 ($dm^3$)

1

**alternative approach:**

(58 MJ =) 58 000 kJ (1)

(energy released per $dm^3$ = $\frac{290}{24}$ =) 12.08333 ($kJ/dm^3$) (1)

(volume =) $\frac{58000}{12.08333}$ (1)

*allow correct use of an incorrectly converted or unconverted value of energy*

*allow correct use of an incorrectly calculated energy released per $dm^3$*

= 4800 ($dm^3$) (1)

**[12]**

## Q6.

(a) HCOOH

*allow $HCO_2H$*

1

propanoic acid

1

(b) incomplete / partial ionisation

*allow incomplete / partial dissociation*

1

(because) reaction is reversible

*allow (because) reaction is in equilibrium*

1

(c) mass (of flask and contents) decreases

1

(because) carbon dioxide is produced

1

(and) carbon dioxide escapes (from the flask)

*allow **1** mark for the gas produced escapes (from the flask)*

1

(d) (0.01 $mol/dm^3$) methanoic acid has a lower pH

*allow converse argument for ethanoic acid*

*allow (0.01 $mol/dm^3$) methanoic acid is a stronger acid*

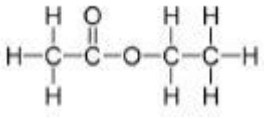
1

(so 0.01 mol/dm³) methanoic acid has a higher concentration of hydrogen ions 1

(therefore) more collisions per unit time 1

(e) ethyl ethanoate 1

(f)

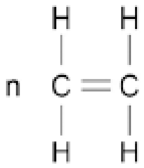


1

**[12]**

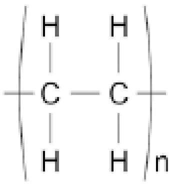
## Q7.

(a) *(ethene)*



1

*(polyethene)*



1

(b) any **four** from:

- poly(ethene) produced by addition polymerisation whereas polyester by condensation polymerisation
- poly(ethene) produced from one monomer wheareas polyester produced from two different monomers
- poly(ethene) produced from ethene / alkene whereas polyester from a (di)carboxylic acid and a diol / alcohol
- poly(ethene) is the only product formed whereas polyester water also produced
- poly(ethene) repeating unit is a hydrocarbon whereas polyester has an ester linkage

4

**[6]**

## Q8.

(a) flame test

*allow description of flame test*

1

lilac (flame) 1

(b) flame emission spectroscopy 1

(c) white precipitate

*ignore precipitate dissolves* 1

(d) (add) excess sodium hydroxide (solution)

*allow (add) more sodium hydroxide (solution)* 1

precipitate dissolves 1

(e) add barium chloride (solution)

*allow add barium nitrate (solution)* 1

add (dilute) hydrochloric acid

*allow add (dilute) nitric acid* 1

white precipitate

*dependent on MP1 being awarded* 1

**[9]**

## Q9.

(a) tin 1

(b) any **one** from:

- ornaments
- musical instruments
- hinges / knobs / screws

*allow any correct use of brass* 1

(c) (**A)** 12 (carat) 1

(**B**) 3 (grams) 1

(d) any **two** from:

- (alloy of gold is) harder
- (alloy of gold is) cheaper
- aesthetic reasons

*allow converse statements about pure gold* 2

(e) any **one** from:

- does not corrode

  *allow will not rust*
- does not react with water
- is hard

1

(f) low carbon steel

1

**[8]**

## Q10.

(a)

*an answer of 17.6470588 (%) correctly rounded to at least 2 significant figures scores 2 marks*

$\frac{6}{34} \times 100$

1

= 17.6 (%)

*allow 17.6470588 (%) correctly rounded to at least 2 significant figures*

1

(b)

*allow converse arguments in terms of higher pressure*
*ignore references to rate*

higher yield (of hydrogen or carbon monoxide or product)

*allow more hydrogen or more carbon monoxide or more product*
*allow equilibrium moves to the right*
*allow equilibrium moves in the forward direction*

1

(because) fewer moles / molecules / particles on left hand side
**or**
(because) more moles / molecules / particles on right hand side

*allow (because) the reverse reaction produces fewer moles / molecules / particles*
***or***
*allow (because) the forward reaction produces more moles / molecules / particles*

*do **not** accept fewer / more atoms*

1

(c) no effect (on yield of hydrogen)

*allow position of equilibrium unaffected by pressure*

*ignore references to rate of reaction*

1

(d)

*an answer of 2.25 scores **3** marks*

350 (°C) and 285 (atmospheres) = 63 (%)

**and**
450 (°C) and 200 (atmospheres) = 28 (%)

*allow a value between 62 (%) and 64 (%) inclusive*

1

$\frac{63}{28}$

*allow a correct expression using incorrectly determined value(s) for percentage yield*

1

= 2.25 (times greater)

*allow a correct calculation using incorrectly determined value(s) for percentage yield correctly evaluated and rounded to at least 2 significant figures*

1

(e)

*allow converse arguments in terms of low(er) pressure*

any **one** from:

- the energy costs would be high(er)
  *ignore energy / cost unqualified*
- the equipment would need to be strong(er)
  *allow the equipment would be (more) expensive (to build / maintain)*
- high(er) pressures are (more) dangerous
  *allow (more) dangerous because (greater) risk of explosion*

1

(f) higher temperatures produce a lower (percentage) yield (of ammonia)

*allow converse*
*allow correct reference to shift in equilibrium*
*ignore references to pressure*

1

(g) world population has increased

1

any **one** from:

- demand for fertiliser has increased
  *allow more food needed*
- increased demand for other specified ammonia-based products e.g. nitric acid, drugs, dyes, explosives

1

**[12]**

## Q2.

(a) Approximately a third of students scored a mark for referring to the presence of delocalised electrons in carbon nanotubes.

Very few scored the mark for explaining the role of these electrons in the conduction of electricity.

(b) Most students understood that they needed to compare the properties of the three materials. However, a few did not add value and just quoted data from the table, which is insufficient to be credited.

Approximately 45% of students achieved a Level 2 mark by giving a consequence of one of the stated differences in properties. Some gave a justified conclusion in referencing the most suitable material for a racket frame.

For some students, there was a misunderstanding that a high density was good because it made the racket strong, despite strength being one of the other properties given.

(c) Almost a quarter of students scored full marks for this calculation. A similar proportion correctly calculated the surface area as 40344 $nm^2$ but did not score the mark for converting this answer to standard form.

Some students calculated the volume of the nanoparticle rather than the surface area.

Even if the answer to their calculation was incorrect, a mark could still be scored for correctly converting this answer to standard form, provided that an attempt to calculate the surface area had been made.

(d) Students found it difficult to give a reason why it costs less to use nanoparticles in sun-cream with only approximately 10% scoring the mark.

Common responses seen that were not credited included:
- nanoparticles are smaller
- nanoparticles are easier to make.

## Q4.

(c) Whilst there were many excellent answers, many were very carelessly drawn, with arrows for activation energy and overall energy change being placed so that their start and end were only vaguely near the correct levels. Dotted lines should be drawn to clarify the energy gaps. Some drew the profile for an endothermic change, rather than exothermic, and some did not complete the profile, leaving out the energy level of the products. Some appeared to think that the activation energy is the energy at the peak, rather than the difference between the energy of the reactants and the peak.

(d) A good number of students were successful with this calculation, although some failed to count all of the bonds correctly. Where students made a slip of this nature, or an arithmetic error, it was sometimes impossible to award marks for following through with the method, since there was often a jumble of numbers scattered over the page with no words to explain what was going on. ‘Bonds broken’ and ‘bonds made' should be stated in calculations of this type. Many students did not use the value of 1034 kJ/mol provided.

## Q5.

(a) Many students spotted that the curve was for an endothermic reaction rather than exothermic. Many also realised the activation energy was incorrect but could not always express correctly that activation energy should start at the energy of the reactants rather than the products.

(b) Most students did not score well on this question. There were many vague references to 'better for the environment' without any justification for that statement. Many students referenced the fact that water is the only product, failing to realise that rechargeable cells produce no waste products at all. Others failed to realise that the infrastructure for recharging cells is actually better than that for refuelling with hydrogen. Some students were effectively giving advantages of hydrogen fuel cells over petrol engines, instead of answering the question. Others failed to express themselves clearly; saying that hydrogen fuel cells take less time to charge which did not gain credit, as the cells are refuelled, not recharged.

(c) Many students did not realise that either hydrogen or oxygen had to be a reactant. Many impossible species such as $e^{2-}$ or $O_2^+$ were seen.

(d) Many students were able to score at least one mark but only one in six scored both. Many noted that the movement of the particles was not shown; many also noted that the particles are not shown as diatomic, or that the forces between them are not shown.

(e) This was quite well answered, with most students favouring compressing the gas rather than cooling to condense the gas. A number of students incorrectly stated that hydrogen can be taken in from the atmosphere.

(f) A third of students were able to score full marks. It was not possible to give partial credit for working when the students did not explain what they were doing; too often there was a jumble of numbers with various operators between them, with no words or units. No credit was given for multiplying a value by 24 unless that value was identified as a number of moles.

## Q6.

(a) Propanoic acid was named correctly much more often than a correct formula was given for methanoic acid. CHCOOH was a commonly seen error here.

(b) Many students scored at least one mark here. A common misconception was that incomplete / partial ionisation means that each $CH_3COOH$ molecule produces only one $H^+$ ion, i.e. that the three hydrogen atoms in the $CH_3COO^-$ ion would also form $H^+$ ions if ionisation were complete.

(c) This part was quite well answered. Most students stated that the mass decreases. Not all of the students who identified carbon dioxide as a product of the reaction went on to explain that it is the escape of this gas that causes the mass to decrease.

(d) This part was poorly answered by many students. Many recognised that the pH of methanoic acid was lower but far fewer made the link to hydrogen ion concentration. Only a small proportion of students referred to collisions between particles and, of those that did, a significant minority referred to 'more collisions', which was insufficient for the mark, or incorrectly justified the increased collision frequency in terms of the particles having more energy.

(e) A minority of students were able to name ethyl ethanoate.

(f) A majority of students were able to identify the displayed structural formula of ethyl ethanoate.

## Q8.

(a) Over half of the students knew that a flame test should be used but fewer knew the correct result for potassium.

(b) Only a few students mentioned flame emission spectroscopy as an instrumental alternative to a flame test.

(c) Just over a third of students gave white precipitate.

(d) Very few students were able to complete the steps needed to differentiate between metal ions producing a white metal hydroxide precipitate.

(e) Students found this difficult with many students unable to go beyond the need to acidify the solution being tested.

## Q10.

(a) Nearly half of the students scored both marks. Students who provided incorrect responses either ignored the stoichiometry of the equation or did not know the expression which represents atom economy.

(b) The idea that lower pressure increases the yield was understood by many of the students but some had difficulty explaining why. Around a third of the students scored both marks.

(c) Around a third of the students scored this mark. The fact that there was the same number of moles on each side of the equation was often ignored by students. Instead, these responses focused on an increase in pressure increasing the rate of reaction and therefore assumed that this would increase the yield.

(d) This was well done by many of the students although reading the graph was problematic for some. Misinterpreting the *y*-axis scale and/or using a wrong curve were the most frequently seen sources of error. Around two-thirds of the students scored all three marks.

(e) Most students recognised that 285 atmospheres is more expensive but many failed to explain why in terms of energy or cost of plant construction. There were also many vague references to danger or safety. Around a third of the students scored this mark.

(f) Around half of the students scored this mark, having interpreted the graphs correctly and recognised that increasing / decreasing the temperature decreases / increases the yield of ammonia.

(g) Many students recognised that the world population had increased since 1950 and that the demand for food had also increased. Students who did not gain the second mark did not relate the increase in demand for ammonia to an ammonia-based product. Around 40% of the students gained both marks.