Mark schemes

Q1.

(a)   (zinc-carbon) cheap(est)

1

(alkaline) long(est) lasting

1

(nickel-metal hydride) rechargeable
            allow do not have to be thrown away

1

(b)   any **one** from:
   •   (metal / alkaline waste) can be toxic / harmful / corrosive
            allow (batteries) can ignite / explode
   •   (metal / alkaline waste) could cause pollution in landfill sites
   •   recycling would save resources
            ignore dangerous

1

(c)   copper and iron

1

(d)   any **one** from:
   •   temperature (of electrolyte / solution)
   •   concentration (of electrolyte / solution)
            ignore type of electrode / electrolyte
            allow size / mass / length of electrode
            allow surface area of electrode
            allow distance between electrodes
            allow volume of solution / electrolyte

1

(e)   hydrogen
            allow H_2

1

oxygen
            allow O_2

1

[8]

Q2.

(a)   water
            allow H_2O
            *do **not** accept energy*

1

(b)   W = energy

1

X = activation energy

1

Y = overall energy change

1

Z = progress of reaction

1

(c)   to produce a potential difference

1

(d)   magnesium **and** copper

1

(the metals) have the largest difference in reactivity

1

[8]

Q3.

(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

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

   allow $H_2 - 2\ e^- \rightarrow 2\ H^+$

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

   allow $H_2 + 2\ OH^- - 2\ e^- \rightarrow 2\ H_2O$

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

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

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 = $\dfrac{58000}{290}$ **or** $\dfrac{58}{0.290}$

   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 (dm³)

1

alternative approach:

(58 MJ =) 58 000 kJ (1)

(energy released per $dm^3 = \dfrac{290}{24}$ =) 12.08333 (kJ/dm³) (1)

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

> *allow correct use of an incorrectly converted or unconverted value of energy*
>
> *allow correct use of an incorrectly calculated energy released per dm³*

= 4800 (dm³) (1)

[12]

Q4.

(a) concentration (of solution / electrolyte)

1

temperature (of solution / electrolyte)

> *ignore room temperature*
> *allow volume (of solution / electrolyte)*
> *allow size of electrodes*
> *allow distance between electrodes*
> *do **not** accept electrode **X** unqualified*
> *do **not** accept (measured) voltage*

1

(b) (most reactive) magnesium

> *allow Mg*

zinc

> *allow Zn*

(least reactive) cobalt

> *allow Co*

1

(c) 0 (volts)

1

two different metals are needed to produce a voltage

> *dependent on voltage being given as 0 volts*
> *allow the two electrodes are the same metal*
> *allow there is no difference in reactivity (between the electrodes)*

1

(d)   connect cells (in series)

ignore putting cells together

1

use $\left(\frac{12}{1.5} =\right)$ 8 cells

1

(e)   electric toy

1

(f)   (advantage)
any **one** from:
- faster to refuel (than recharging)
- can travel further (before refuelling)
  allow lasts longer
- hydrogen can be renewable
  allow hydrogen is renewable
- produces a constant voltage
- no toxic chemicals released after disposal
  allow the only product is water
  ignore no emissions

1

(disadvantage)
any **one** from:
- hydrogen is made from fossil fuels
- hydrogen is made from non-renewable resources
- hydrogen is difficult to store
- hydrogen is flammable / explosive
- costs more to refuel (than recharging)
- costs more to manufacture
  ignore expensive unqualified
- not many hydrogen filling stations

1

[10]

Q5.

(a)   any **two** from:
- temperature (of solution)
  ignore room temperature
- concentration of electrolyte / solution
- compound / ions in electrolyte / solution

  allow volume of electrolyte / solution

  allow size of electrode

  allow distance between electrodes

  *do **not** accept electrode **X** unqualified*

  *do **not** accept (measured) voltage*

2

(b)   order:
(most reactive) magnesium
cobalt
nickel

> tin
>
> copper
>
> (least reactive) silver
>
> *allow **1** mark for magnesium, cobalt,*
> *nickel, tin in order at top*
>
> *allow **1** mark for copper and silver in*
> *order at the bottom*

2

justification:

the higher the (positive) voltage, the more reactive (the metal)

allow the most reactive (metal) has the
highest voltage

1

silver has a negative voltage because silver is less reactive than copper

1

(c)   magnesium and tin

1

(d)   (in a fuel cell) hydrogen is oxidised (to produce water)

allow (in a fuel cell) hydrogen reacts
with oxygen (to produce water)

1

water is produced / released as gas / vapour / steam

*if no other mark awarded, allow **1** mark for fuel cells*
produce water

1

[9]

Q6.

(a)   copper, zinc, sodium chloride solution

1

(b)   a reactant is used up

allow the reaction stops

allow electrolyte / electrode / ions /
metal / metal hydroxide / alkali for
reactant

1

(c)   the reaction is not reversible

1

(d) $2H_2 + O_2 \rightarrow 2H_2O$

allow fractions / multiples

*allow **1** mark for O_2*

2

(e)   **Level 3:** A judgement, strongly linked and logically supported by a
sufficient range of correct reasons, is given.

5−6

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

3−4

Level 1: Relevant points are made. This is not logically linked.

1−2

No relevant content

0

Indicative content

reasons why fuel cells could be judged as better

from the table	from other knowledge
• time for refuelling a fuel cell is faster than recharging **or** a fuel cell does not need to be recharged • a fuel cell has a greater range	• hydrogen can be renewable if made by electrolysis using renewable energy • lithium-ion batteries can catch fire • produces only water **or** no pollutants produced • lithium-ion batteries may release toxic chemicals on disposal • lithium-ion batteries (eventually cannot be recharged so) have a finite life

reasons why the lithium-ion battery could be judged as better

from the table	from other knowledge
• lithium-ion uses energy more efficiently • cost of lithium-ion car much less • cost of recharging much less than refuelling with hydrogen	• hydrogen is often made from fossil fuels so is not renewable • charging points are more widely available than hydrogen filling stations • hydrogen takes up a lot of space **or** is difficult to store • hydrogen can be highly flammable / explosive • no emissions produced • (catalyst in the hydrogen fuel-cell eventually becomes poisoned so) have a finite life

[11]

Q7.

(a)   magnesium
zinc
iron
tin
(copper)

*three in the correct order scores **1** mark*

*all correct scores **2** marks*

2

(b)   use 4 cells (each of voltage 1.5 V)

1

connect in series

1

(c)   reaction stops

1

(because) one of the reactants is used up

1

(d)   (hydrogen +) oxygen ($\rightarrow$ water)

1

(e)   any **two** from:
- produces water
- water is not harmful / polluting
- does not produce carbon dioxide
- does not produce other named pollutant

*allow an answer of **only** produces water for **2** marks*

2

[9]

Q8.

(a)   the chemical reaction is reversible

1

(b)   any **two** from:
- type of electrode
- electrolyte
- concentration of electrolyte
- temperature

2

(c) $H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$

allow multiples

1

(d)   contains OH^- ions

1

(e)   (bonds broken)

$((6 \times 412) + (2 \times 360) + (2 \times 464) + (3 \times 498)) = 5614$

1

(bonds made)
$((4 \times 805) + (8 \times 464)) = 6932$

1

(overall energy change)
$(6932 - 5614) = -1318$ (kJ / mol)

*allow ecf from marking point 1 and / or marking
point 2*

1

*an answer of 1318 (kJ / mol) scores **3** marks*

[8]

Q9.

(a)   (zinc has) lost electron(s)

accept loss of electrons

1

(b)   copper is the least reactive

1

because it gave the most negative voltage when it was metal 2
or
it gave the biggest voltage with chromium
or
it gave the most positive voltage when it was metal 1

1

(c) -0.7 V

1

The voltage with chromium and copper is 1.2

*accept use of other cell pairings such as tin with
copper and tin with iron*

1

The voltage with chromium and iron is 0.5 and copper is less reactive (than
iron)

1

(d)   hydrogen + oxygen = water

1

(e) $H_2 \rightarrow 2H^+ + 2e^-$

1

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

1

[9]