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 H2

1

oxygen

allow O2

1

[8]

Q2.

(a) water

allow H2O
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

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

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

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

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

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

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

1

(d) any two from:

- hydrogen is not shown as H2 / 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 (dm3)

1

alternative approach:

(58 MJ =) 58 000 kJ (1)

(energy released per dm3 = $\frac{290}{24}$ =) 12.08333 (kJ/dm3) (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 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 (→ 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 × 412) + (2 × 360) + (2 × 464) + (3 × 498)) = 5614

1

(bonds made)
((4 × 805) + (8 × 464)) = 6932

1

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

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

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

1

[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]