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

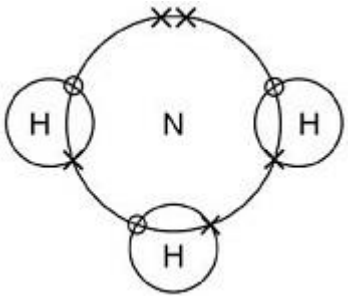
ignore units

1

[11]

Q2.

(a)



*scores **2** marks*
allow dots, crosses, circles or $e^{(-)}$ for electrons

1 bonding pair of electrons in each overlap

1

2 non-bonding electrons on nitrogen

*do **not** accept non-bonding electrons on hydrogen*

ignore inner shell electrons drawn on nitrogen

1

(b) does not show the shape
or
only two-dimensional

allow is not three-dimensional

1

(c) (ammonia has) small molecules

allow (ammonia has) a simple molecular (structure)

1

(ammonia has) weak intermolecular forces

allow (ammonia has) weak intermolecular bonds

*do **not** accept weak covalent bonds*

1

(so) little energy is needed to overcome the intermolecular forces

allow (so) little energy is needed to break the intermolecular bonds
allow (so) little energy is needed to separate the molecules

*do **not** accept references to breaking covalent bonds*

1

(d) Cr_2O_3

1

(e)

*an answer of (-)1272 (kJ) scores **3** marks*

(for bonds broken)
((12 x 391) + (3 x 498) =) 6186

1

(for bonds made)
((2 x 945) + (12 x 464) =) 7458

1

(overall energy change = 6186-7458 =) (-)1272 (kJ)

allow correct calculation using incorrectly calculated values from step 1 and/or step 2

1

(f)

allow ecf from part (e)

7458 (kJ) (released in making bonds) is greater than 6186 (kJ) (used in breaking bonds)
or
the products have 1272 (kJ) less energy than the reactants

allow the (overall) energy change is -1272 (kJ)

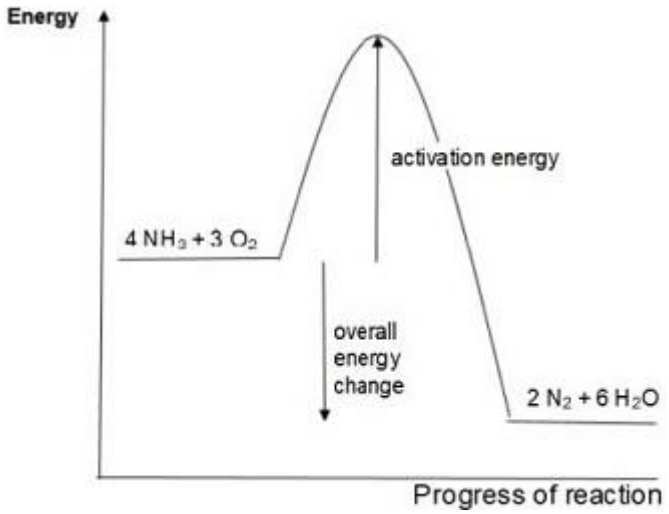
1

(so) energy is released (to the surroundings)

dependent on MP1 being awarded
allow (so) heat is released (to the surroundings)
*if no values given, allow **1** mark for more energy released in making bonds than used in breaking bonds*

1

(g)



*scores **2** marks*
allow discontinuous lines
ignore arrow heads

activation energy labelled

1

(overall) energy change labelled

1

[14]

Q3.

(a) chlorine is toxic

allow carbon monoxide is toxic
allow poisonous for toxic
ignore harmful / deadly / dangerous
allow a poisonous gas is used / produced
allow titanium chloride is corrosive

1

(b) any **one** from:

- very exothermic reaction

allow explosive
allow violent reaction
ignore vigorous reaction
ignore sodium is very reactive

- produces a corrosive solution

  allow caustic for corrosive
  ignore alkaline
- produces hydrogen, which is explosive / flammable

  allow flames produced
  ignore sodium burns

1

(c) argon is unreactive / inert

allow argon will not react (with reactants / products / elements)

1

oxygen (from air) would react with sodium / titanium
or
water vapour (from air) would react with sodium / titanium

allow elements / reactants / products for sodium / titanium

1

(d) metal chlorides are usually ionic

allow titanium chloride is ionic

1

(so)(metal chlorides) are solid at room temperature
or
(so)(metal chlorides) have high melting points

allow titanium chloride for metal chlorides

1

(because) they have strong (electrostatic) forces between the ions

ignore strong ionic bonds

or
(but) must be a small molecule or covalent

allow molecular

1

allow alternative approach:

*titanium chloride must be covalent **or** has small molecules (1)*

*with weak forces between molecules do **not** accept bonds unless intermolecular bonds(1)*

(but) metal chlorides are usually ionic (1)

(e) sodium (atoms) lose electrons

*do **not** accept references to oxygen*

1

(f) $Na \longrightarrow Na^{+} + e^{-}$

*do **not** accept e for e^{-}*

1

(g) (M_r of $TiCl_4$ =) 190

$$(\text{moles Na} = \frac{20\,000}{23} =) \ 870 \text{ (mol)} *$$

1

$$(\text{moles } TiCl_4 = \frac{40\,000}{190} =) \ 211 \text{ (mol)} *$$

1

allow **1 mark for 0.870 mol Na **and** 0.211 mol $TiCl_4$*

allow use of incorrectly calculated M_r from step 1

either

(sodium is in excess because) 870 mol Na is more than the 844 mol needed

or

(because) 211 mol $TiCl_4$ is less than the 217.5 mol needed

the mark is for correct application of the factor of 4

other correct reasoning showing, with values of moles or mass, an excess of sodium or insufficient $TiCl_4$ is acceptable

allow use of incorrect number of moles from steps 2 and / or 3

1

alternative approaches:

approach 1:

(M_r of $TiCl_4$ =) 190(1)

(40 kg $TiCl_r$ needs)

$$\frac{40}{190} \times 4 \times 23 \text{ (kg Na) (1)}$$

(=) 19.4 (kg) (1)

so 20 kg is an excess (1)

approach 2:

(M_r of $TiCl_4$ =) 190(1)

(20 kg Na needs)

$$\frac{20}{4 \times 23} \times 190 \text{ (kg } TiCl_4 \text{) (1)}$$

(=) 41.3 (kg) (1)

so 40 kg is not enough (1)

(h) $(\text{actual mass} =) \frac{92.3}{100} \times 13.5$

or

(actual mass =) 0.923 × 13.5

1

= 12.5 (kg)

allow 12 / 12.46 / 12.461 / 12.4605 (kg)

1

*an answer 12.5 (kg) scores **2** marks*

[15]

Q4.

(a) incomplete combustion

1

(because) insufficient / limited oxygen supply

1

(b) any **two** from:

- carbon monoxide toxic / poisonous

  allow description of how carbon monoxide is toxic / poisonous
  ignore carbon monoxide is harmful / dangerous / deadly

- greater public concern / awareness about pollution

  ignore comments about the effects of other pollutants

  ignore unspecified comments about carbon monoxide pollution

- more cars so otherwise there would be more carbon monoxide entering atmosphere

- improved engine technology

- catalytic converters have been introduced

2

(c) any **one** from:

- (to reduce) health problems

  allow (to reduce) specified health problems e.g. breathing difficulties, asthma, lung cancer

- (to reduce) global dimming

  allow (to reduce) the effects of global dimming e.g. reduced light levels

  allow (to reduce) smog
  allow (to reduce) the formation of particulates

ignore global warming
*do **not** accept to reduce soot*

1

(d) nitrogen (from atmosphere) reacts with oxygen (from atmosphere)

1

at high temperature (in engine)
ignore heat / hot

or
with a spark (from spark plug)

1

(e) **2** $NO_2 \longrightarrow N_2$ + **2** O_2
allow multiples
*if incorrect, allow N_2 for **1** mark*

2

(f) any **one** from:
- acid rain
  allow specific effects of acid rain
- respiratory problems
  allow specific respiratory problems e.g. breathing difficulties, asthma
- carbon monoxide
- global dimming **or** smog

2

***max 1** mark if global warming mentioned*

(g) transition metals

1

[12]

Q5.

(a) in a closed system

1

the rate of the forward and backward reactions are equal

1

(b) concentration increases

1

(because) reaction / equilibrium moves to the left / reactant side

1

(since the) reverse reaction is exothermic
allow (so that) temperature increases

1

(c) becomes blue

1

(because) reaction / equilibrium moves to the right / product side

1

(so) concentration of blue cobalt compound increases

allow (so that) concentration of hydrochloric acid decreases

1

(d) (cobalt has) ions with different charges

allow (cobalt is a) transition metal

1

(e) Co^{3+}

1

(f) they allow reactions to reach equilibrium more quickly

1

they provide a different reaction pathway

1

(g) $\mathbf{13}H_2 + \mathbf{6}CO \rightarrow C_6H_{14} + \mathbf{6}H_2O$

allow multiples

1

(h) C_8H_{18}

1

(i) curve below printed curve

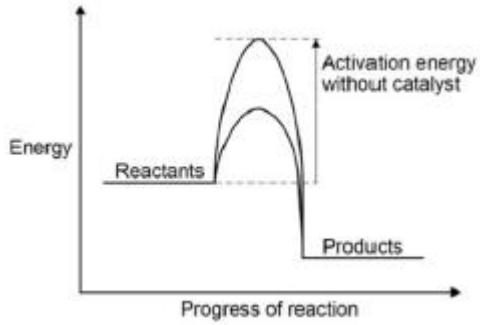
*do **not** accept different reactant or product levels*

1

vertical arrow from reactant level to peak of **printed** curve

1

an answer of:



scores **2** marks

[16]

Q6.

(a) 13 (protons)

The answers must be in the correct order.

*if no other marks awarded, award **1** mark if number of protons and electrons are equal*

1

14 (neutrons)

1

13 (electrons)

1

(b) has three electrons in outer energy level / shell

allow electronic structure is 2.8.3

1

(c) **Level 3 (5–6 marks):**
A detailed and coherent comparison is given, which demonstrates a broad knowledge and understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links.

Level 2 (3–4 marks):
A description is given which demonstrates a reasonable knowledge and understanding of the key scientific ideas. Comparisons are made but may not be fully articulated and / or precise.

Level 1 (1–2 marks):
Simple statements are made which demonstrate a basic knowledge of some of the relevant ideas. The response may fail to make comparisons between the points raised.

0 marks:
No relevant content.

Indicative content

Physical
Transition elements
- high melting points
- high densities
- strong
- hard

Group 1
- low melting points
- low densities
- soft

Chemical
Transition elements
- low reactivity / react slowly (with water or oxygen)
- used as catalysts
- ions with different charges
- coloured compounds

Group 1
- very reactive / react (quickly) with water / non-metals

- not used as catalysts
- white / colourless compounds
- only forms a +1 ion

6

[10]