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

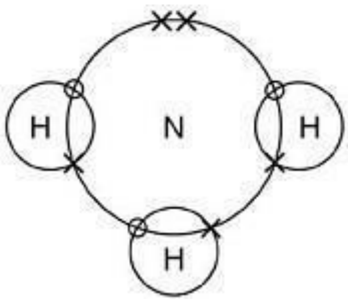
ignore units

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) Cr2O3

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

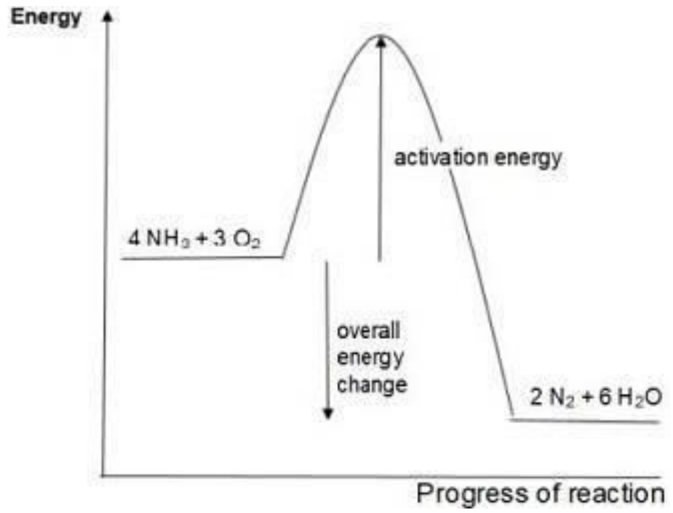
(so) energy is released (to the surroundings)

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 TiCl4 =) 190

$(\text{moles Na} = \frac{20000}{23} =)\ 870\ (\text{mol})\ *$

1

$(\text{moles } TiCl_4 = \frac{40000}{190} =)\ 211\ (\text{mol})\ *$

1

**allow 1 mark for 0.870 mol Na and 0.211 mol TiCl4*

allow use of incorrectly calculated Mr from step 1

either
(sodium is in excess because) 870 mol Na is more than the 844 mol needed
or
(because) 211 mol TiCl4 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 TiCl4 is acceptable

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

1

alternative approaches:

approach 1:

(Mr of TiCl4 =) 190(1)

(40 kg TiClr 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:

(Mr of TiCl4 =) 190(1)

(20 kg Na needs)

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

(=) 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) $2NO_2 \longrightarrow N_2 + 2O_2$
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) Co3+
1

(f) they allow reactions to reach equilibrium more quickly
1

they provide a different reaction pathway
1

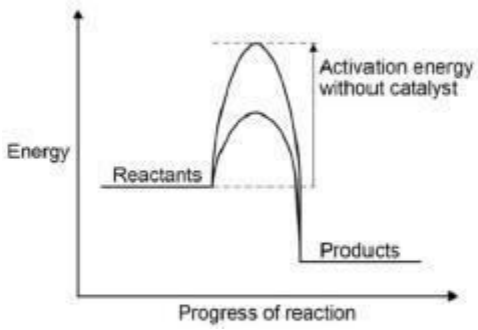
(g) 13H2 + 6CO → C6H14 + 6H2O
allow multiples
1

(h) C8H18
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]