AQA GCSE CHEMISTRY (HIGHER) · 8462

CHEMISTRY



MARK SCHEME

4.1.3 PROPERTIES OF TRANSITION METALS

SCORE	PERCENTAGE
/162	%

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Q1.

(a) FeS_2

*do **not** accept equations*

1

(b) 26

1

30

1

26

1

must be this order

(c) any **two** from:

- iron has a high(er) melting / boiling point
- iron is dense(r)
- iron is hard(er)

allow iron is less malleable / ductile

- iron is strong(er)
- iron is less reactive

allow specific reactions showing difference in reactivity

- iron has ions with different charges
- iron forms coloured compounds
- iron can be a catalyst

allow iron is magnetic

allow the converse statements for sodium
allow transition metal for iron
allow Group 1 metal for sodium

ignore references to atomic structure

ignore iron rusts

2

(d) carbon is more reactive (than nickel)

allow converse

1

(so) carbon will displace / replace nickel (from nickel oxide)

allow (so) nickel ions gain electrons

or

(so) carbon will remove oxygen (from nickel oxide)

allow (so) carbon transfers electrons to nickel (ions)

1

(e) (total M_r of reactants =) 87

1

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(percentage atom economy)

$= \frac{59}{87} \times 100$

allow (percentage atom economy)
$= \frac{59}{\text{incorrectly calculated } M_r} \times 100$

1

= 67.8 (%)

allow an answer from an incorrect calculation to 3 sig figs

1

*an answer of 67.8 (%) scores **3** marks*
*an answer of 67.8160919 (%) or correctly rounded answer to 2, 4 or more sig figs scores **2** marks*
an incorrect answer for one step does not prevent allocation of marks for subsequent steps

[11]

Q2.

(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

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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

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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]

Q3.

(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

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- 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*

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(g) transition metals

1

[12]

Q4.

(a) **J**

1

(b) **M** and **Q**

either order

1

(c) **Q**

1

(d) **M**

1

(e) **L**

1

(f) **Level 3 (5-6 marks):**
A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.

Level 2 (3-4 marks):
Some logically linked reasons are given. There may also be a simple judgement.

Level 1 (1-2 marks):
Relevant points are made. They are not logically linked.

Level 0
No relevant content

Indicative content

comparative points
- both tables have more than one element in a box
- both have similar elements in the same column
- both are missing the noble gases
- both arranged elements in order of atomic weight

advantages of Mendeleev / disadvantages of Newlands
- Newlands did not leave gaps for undiscovered elements
- Newlands had many more dissimilar elements in a column
- Mendeleev left gaps for undiscovered elements
- Mendeleev changed the order of some elements (e.g. Te and I)

points which led to the acceptance of Mendeleev's table
- Mendeleev predicted properties of missing elements
- elements with properties predicted by Mendeleev were discovered
- Mendeleev's predictions turned out to be correct
- elements were discovered which fitted the gaps

6

[11]

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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*

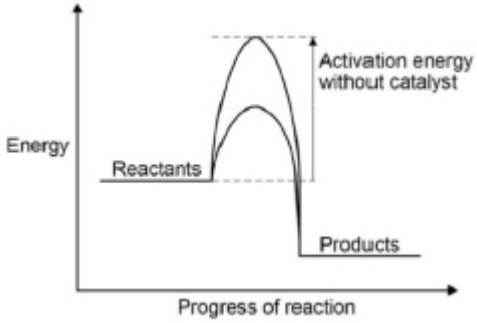
1

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

1

an answer of:

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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

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- 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]

Q7.

(a) (i) central block

1

(ii) conducts electricity

1

(b) any **two** from:

- visual pollution
- noise pollution
- dust pollution
- habitat destruction.

2

(c) (i) to concentrate the ore / copper carbonate
or
to remove / separate the rock

1

(ii) 12 (tonnes)

If answer is incorrect allow one mark for (127 + 132) − 247 or 259 - 247

2

(iii) any **one** from:

- so no reactant is wasted / left unreacted
- so they know how much product they will make
- need to record / compensate for the carbon dioxide produced

allow so they can work out their carbon footprint.

1

[8]

Q8.

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(a) The ore is not pure or contains impurities or the ore does not contain 100% of the metal compound

allow to concentrate the metal or metal compound

1

rock / other compounds need to be removed / separated

1

(b) (i) (cast iron is) brittle

allow not strong

ignore weak

1

(ii) the oxygen reacts with carbon

allow carbon burns in oxygen or is oxidised

1

reducing the percentage of carbon in the mixture
or producing carbon dioxide

1

(c) (i) aluminium has a low density

1

(ii) (because copper) is in the central / middle (block of the periodic table)

1

whereas aluminium is in Group 3 (of the periodic table)

1

(iii) iron is more reactive (than copper)

ignore cost

1

so copper is displaced / reduced

1

[10]

Q9.

(a) (i) **A**

1

(ii) **F**

1

(iii) **E**

1

(iv) **C**

1

(v) **A or B**

1

(b) (i) Rb K Na

allow rubidium, potassium, sodium

*do **not** accept RB or NA*

1

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(ii) decrease

or

become lower / smaller / less
allow from 180° C to 27° C

1

(c) They are harder than Group 1 metals.

1

They have higher melting points than Group 1 metals.

1

They often form coloured compounds but Group 1 compounds are usually white.

1

[10]

Q10.

(a) (i) UI / solution turns blue / purple
allow violet / lilac

1

any **two** from:

- floats
- melts / forms a sphere
- moves
  *note: moves on surface = **2** marks (points 1 and 3)*
- effervescence / fizz / bubbles / gas
  ignore the name of the gas
- (yellow) flame
  ignore sparks / ignites / burns
  allow dissolves
- reduces in size
  ignore 'reacts violently' unqualified
  ignore reference to exothermic / heat evolved

2

(ii) **2**Na + **2**H_2O → **2NaOH** + H_2
*correct equation = **2** marks*
allow correct multiples / fractions
if this equation is unbalanced,
*allow **1** mark for NaOH*

2

(b) *it = francium*
*outer electron / shell / energy level must be mentioned once for all **3** marks*

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biggest atom **or** (outer) shell / energy level / electron furthest from nucleus **or** most (number of) shells

1

least attraction (to nucleus) **or** most shielding

allow the attraction is <u>very</u> weak

*do **not** allow less magnetic / gravitational attraction*

1

(outer) electron more easily lost / taken

ignore francium reacts more easily / vigorously

1

(c) any **two** from:

ignore other properties / specific reactions

they / it = transition elements

transition elements:

allow if state group 1 elements

- high melting point **or** high boiling point
  - *low melting point or low boiling point*
- high density
  - *low density*
- strong / hard
  - *weak / soft*
- not very reactive
  - *reactive*
- catalysts
  - *not catalysts*
- ions have different charges
  - *+1 ions*
- coloured compounds
  - *white compounds*

2

[10]

Q11.

(a) (i) elements

1

(ii) atomic weight

1

(iii) atomic (proton) number

1

(b) (i) transition metals

1

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(ii) has a higher melting point is harder

2

[6]

Q12.

(a) tungsten

1

has the high(est) melting point

accept that metals other than tungsten are likely to melt

1

(b) argon

1

is an unreactive gas

accept that gases other than argon are reactive

accept that argon is a noble gas or in Group 0

1

[4]

Q13.

(a) (good)conductor of electricity

conductor of electricity and heat (+/–) = 0

*accept can be drawn into wires **or** ductile*

ignore flexible

1

(b) strong

*accept tough **or** hard **or** high tensile strength*

1

(c) reference to <u>colour</u>

1

[3]

Q14.

conducts heat

list principle applies after 4 ticks

1

forms coloured compounds

1

high melting point

1

strong

1

[4]

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Q15.

(a) colour

1

(b) Fe_2O_3 or $(Fe^{3+})_2\ (O^{2-})_3$

2 and 3 should be below halfway on Fe and O

1

(c) (i) 4 4

or correct multiples

1

(ii) any **two** from:

ignore references to malleable / ductile / conductivity / stiff / boiling point / density

- high melting point
  accept can withstand high temperatures
- strong / tough
  accept <u>not</u> brittle
- hard
  *do **not** accept flexible*
- not (very) reactive

2

[5]

Q16.

(a) 8 marks Particularly well structured answer with most points mentioned.

7-6 marks Well structured answer. The two metals will have been compared rather than simply listing advantages/disadvantages. Most of the advantages and disadvantages of each metal have been mentioned.

5-3 marks Some structure to the answer. An attempt to compare the metals by giving some advantages and disadvantages.

2-1 marks Little structure or attempt to compare. Marks gained by listing a few advantages or disadvantages.

Advantages of Nickel:
Relatively low cost which makes the sparking plugs cheaper to produce.
Quite high melting point which is needed because the temperature in the engine is very high.
Good conductor of electricity needed to carry electricity into combustion chamber to produce spark.

Disadvantages of Nickel:
Subject to corrosion in engine which means they only last a short time

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because nickel is higher in reactivity than platinum.
Idea that this leads to reduced efficiency, unburnt petrol and air pollution.

Advantages of Platinum:
Less susceptible to corrosion (not corroded) because platinum is very low in reactivity.
Idea that this improves efficiency and reduces pollution.-
Higher melting point than nickel to withstand the high temperatures in the combustion chamber.
Last a lot longer than nickel electrodes due to low reactivity.
(Sensible extension here could be longer service intervals etc.)-
Good conductor of electricity as for nickel.
Extension here could be linked to the idea that the conductivity does not deteriorate as quickly as nickel.)

Disadvantages of Platinum:
Cost *which will make the sparking plug more expensive.*
A good candidate might justify cost by longer life, better fuel consumption and less pollution.

8

(b) (i) giant structure/lattice/regular arrangements of atoms
any for 1 mark

of atoms/of ions (provided free electrons mentioned)
either for 1 mark

delocalised or free electrons
for 1 mark

3

(ii) electrons free/can move
for 1 mark each

2

[13]

Q17.

(a) 75% Cu, 25% Ni
for 1 mark

1

(b) 70% segment shaded
for 1 mark

1

(c) (i) copper
for 1 mark

1

(ii) zinc
for 1 mark

1

(d) 1. hard so will not wear away/scratch
for 1 mark

1

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2. unreactive
so does not corrode/dissolve/or other acceptable reason
(not does not react unless acceptable reason)

(If given hard and unreactive allow 1 mark)

for 1 mark

1

[6]

Q18.

(a) transition / transitional metals / elements / d-block

for one mark

1

(b) coloured
catalyst

(*accept* high melting point)

for 1 mark each

2

[3]

Q19.

(i) zinc

accept Zn

1

iron only

accept Fe

1

copper

accept Cu
do not credit iron

1

(ii) iron

1

(iii) copper **or** iron or manganese

*accept Cu **or** Fe **or** Mn*

1

[5]

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