AQA GCSE CHEMISTRY (HIGHER) · 8462

CHEMISTRY



MARK SCHEME

4.5.1 EXOTHERMIC AND ENDOTHERMIC REACTIONS (PACK 3)

SCORE	PERCENTAGE
/208	%

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Q1.

(a) (i) energy / heat of products less than energy of reactants

owtte

allow products are lower than reactants

allow more energy / heat given out than taken in

allow methanol is lower

allow converse

allow energy / heat is given out / lost allow ΔH is negative

1

(ii) lowers / less activation energy

owtte

allow lowers energy needed for reaction

***or** it lowers the peak/ maximum*

*do **not** allow just 'lowers the energy'*

1

(b) (i) bonds broken: (2 × 435) + 498 = 1368

allow: (8 × 435) + 498 = 3978

1

bonds made: (2 × 805) + (2 × 464) = 2538

allow: (6 × 435) + (2 × 805) + (2 × 464) = 5148

1

energy change: 1368 – 2538 = (–)1170

allow: 3978 – 5148 = (–)1170

ignore sign

allow ecf

*correct answer (1170) = **3** marks*

1

(ii) energy released forming new bonds is greater than energy needed to break existing bonds owtte

allow converse

*do **not** accept energy needed to form new bonds greater than energy needed to break existing bonds*

1

[6]

Q2.

(a) (i) high temperature

accept temperature given if ≥ 400 °C

ignore value if "high" stated, unless silly value

1

endothermic or reaction takes in energy

or Δ H is +ve

independent marks

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1

(ii) low pressure

or up to and including 10 atmospheres

1

(low pressure) favours a reaction in which more molecules are formed

2 moles → 4 moles
(2 molecules → 4 molecules)

independent marks

1

(iii) nickel **and** it is a transition / transitional element / metal (owtte) **or** nickel **and** variable oxidation state / number or it is similar to other named transition elements e.g. iron

1

(b) (i) (bonds broken =) 2005 (kJ)

1

(bonds formed =) 2046 (kJ)

1

energy change = 2005 – 2046 = (–)41

for correct subtraction ignore sign

1

(ii) (exothermic)

if in part (b)(i) answer is not 41
answer is consequential on endothermic or exothermic shown

*accept correct reasoning for **incorrect** answer from (b)(i)*

energy given out forming new bonds

*do **not** accept energy needed to form new bonds*

1

greater than energy put in to break old bonds

*accept exothermic **and** more energy given out than taken in for 1 mark*
*accept negative value for energy change **or** energy in products less than energy in reactants for 1 mark*

1

[10]

Q3.

(a) (i) high **and** low

both needed for mark

1

(ii) reversible

1

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(iii) to prevent ammonium chloride / solid / particles escaping

idea of a filter
*do **not** accept 'to prevent gases escaping'*

1

(b) endothermic

1

[4]

Q4.

(a) M_r (SiO_2) = 60

if M_r incorrect ecf for max 2

1

60 g SiO_2 → 28 g Si

*correct answer for **3** marks*

1

2.14 g SiO_2 → 1 g Si

allow 2, 2.1, 2.14 (or anything rounding to 2.14), 2.16 or 2.2
a unit is not required but an incorrect unit loses the third mark

OR M_r (SiO_2) = 60 (1)

moles if silicon needed = $\frac{1}{28}$ = 0.0357

mass of SiO_2 needed = 0.0357 × 60 (1)

= 2.14 g (1)

allow 2, 2.1, 2.14 (or anything rounding to 2.14), 2.16 or 2.2

OR M_r (SiO_2) = 60 (1)

mass SiO_2 = 1 × $\left(\frac{60}{28}\right)$ (1)

= 2.14 g (1)

allow 2, 2.1, 2.4 (or anything rounding to 2.14), 2.16 or 2.2

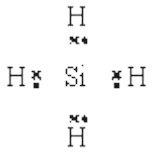
3

(b) (i) $MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$

*penalise incorrect symbols correctly balanced equation for **1** mark state symbols for **1** mark*
allow correct multiples / fractions

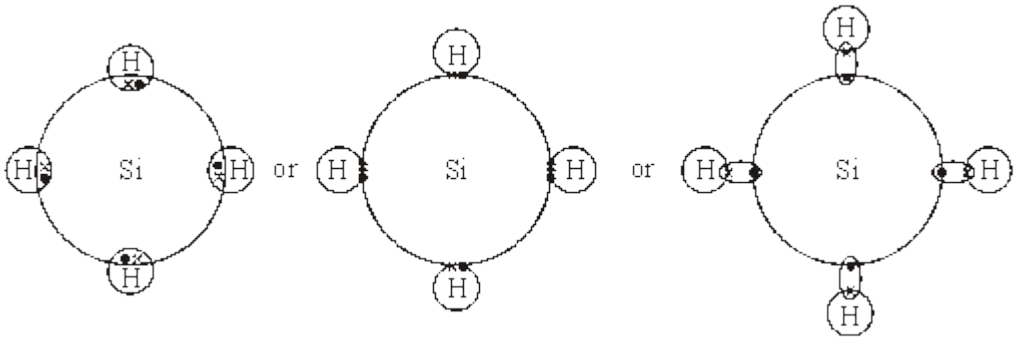
2

(ii)



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or



ignore inner shell electrons of silicon
allow correct drawings without symbols
must clearly indicate four shared pairs of electrons with one electron from each atom

(iii) **Si** **H**

$\frac{1.4}{28}$ $\frac{0.15}{1}$

1

= 0.05 = 0.15

1

1 3

for whole number ratio can be implied

1

SiH_3

accept H_3Si ***or*** *any correct formula with 1:3 ratio*
if in step 1 they get either of ratios incorrect they lose first 2 marks but can be ecf for 3rd and 4th mark
evidence of mass / A_r ***1*** *mark*
proportions of each ***1*** *mark*
whole number ratio ***1*** *mark*
correct formula ***1*** *mark*

1

(iv) **C**

accept c

1

(c) any **four** from:

- giant structure / macromolecule / lattice / giant molecule
  allow giant molecular / giant atomic structure
- each silicon atom joined to four other atoms
  (or diagram)
- covalent bonds
- bonds are strong **or** large amount of energy needed to break bonds
  accept hard to break bonds

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- large number of bonds to be broken

*mention of giant **ionic** structure **or** intermolecular forces **or** intermolecular bonds max **1** mark*

*diamond **or** carbon discussion max **3** marks unless clearly linked to silicon*

4

[15]

Q5.

(a) sodium
hydrogen
phosphorus
oxygen

***2** marks for all 4*
***1** mark for 2 or 3*
***0** marks for 0 or 1*
not symbols / formulae

2

(b) (i) gives out

gets hot(ter) / temperature rises (1)

1

heat / energy

independent mark

1

(ii) **Quality of written communication**

for clearly expressed ideas

1

take temperature of water at start

owtte

1

take temperature after adding soup powder

1

plus any **one** from:

- using a thermometer
- mix / stir / shake etc
- in beaker / conical flask / test tube / plastic cup
- temperature will rise (indicates an exothermic reaction)

1

[8]

Q6.

(a) (i) yield increases

two marks are linked

1

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because more (gaseous) reactant molecules / particles than (gaseous) product molecules / particles

accept 7 → 4 moles or volumes
ignore more reactants
accept fewer particles on the right

1

(ii) increased (rate) / faster / speeds up etc

two marks are linked

1

more collisions **or** increased concentration **or** particles closer together

greater chance of more successful collisions

1

(b) heat / high temperatures

*do **not** accept burn it ignore cracking / catalyst*

1

[5]

Q7.

(i) 436 + 242 = 678 (kJ) [1]

2 × 431 = 862(kJ) [1]

answer = 184

*first **two** marks can be awarded if answer is incorrect*
ignore sign

3

(ii) exothermic

1

more energy released by, bond formation than needed for bond breaking

both parts to be marked depending on answers given in (b)(i)

1

(iii) hydrogen chloride is (a) covalent (compound)

1

when added to water it forms ions **or** H^+ (and Cl^-)

1

hydrogen ions **or** H^+ causes a solution to be acidic

1

[8]

Q8.

(a) exothermic (reaction)

1

(b) smaller lumps react faster
or larger lumps react slower

accept smaller lumps cause a more rapid rise in temperature
***or** vice versa*

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*do **not** accept higher temperature*
***or** more heat unless linked to time*

1

smaller lumps have a larger surface (area) or larger lumps have a smaller surface (area)

more water can react at the same time
***or** so less water can react at the same time*

1

(c) heats up (too) rapidly

accept temperature (too) high

1

burning the food **or** the hands

*accept danger of container exploding **or** splitting **or** food overheating*

do not accept reference to handling of powder

*do **not** accept a lot of powder needed **or** powder getting into food **or** too hot to eat **or** food would not cook properly **or** heat through properly*

1

[5]

Q9.

rises as energy needed for bond breaking (of reactants)

1

called activation energy **or** correctly labelled on diagram

1

bond making (to form products) releases energy

1

called exothermic reaction **or** more energy given out than taken in **or** releases heat to the surroundings

1

[4]

Q10.

(i) the energy needed by reactants before reaction can occur

accept energy required for particles to collide successfully

accept energy required to break bonds

accept energy needed to start reaction

1

(ii) reference to reactants 'energy' higher than products 'energy'

accept exothermic reaction

accept heat (energy) released

1

melting point of iron is exceeded

accept temperature is above melting point of iron

1

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[3]

Q11.

(a) (i) fertilisers

for 1 mark

1

(ii) 7

for 1 mark

1

(iii) 5

for 1 mark
(ignore other units)

1

(b) (i) both nitrogen and hydrogen

for 1 mark

1

(ii) two of:
nitrogen;
hydrogen/methane/natural gas;
oxygen/air;
water;
any fuel
(allow symbols, do not allow nitrogen oxides)

any two for 1 mark each

2

(c) (i) alkali/alkaline/base/basic

for 1 mark

1

(ii) must be nitrate

for 1 mark

1

(iii) thermometer or any other temperature measuring device

for 1 mark

1

[9]

Q12.

(a) gives out

heat

each for 1 mark

2

(b) chromium and aluminium oxide

1

(c) (i) chromium oxide

1

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(ii) oxygen removed/gains electrons

1

[5]

Q13.

(a) oxygen/O_2

for 1 mark

1

(b) water/H_2O

for 1 mark

1

(c) carbon dioxide/CO_2
(if symbols are used they must be correct)

for 1 mark

1

(d) gives out

for 1 mark

1

heat or energy (2 independent marks)

for 1 mark

1

[5]

Q14.

(a) (i) 4 E (H-O) = 4 × 464 = 1856
2 E (O-O) = 2 × l46 = 292

gains 1 mark each

but Total = 2148 kJ
Deduct one mark for each mistake.
Answer of 1074 kJ gains 1 mark. (Candidate has ignored the 2 in front of the brackets.)

gains 2 marks

2

(ii) 4 E (H-O) = 4 × 464 = 1856
E (O=O) = 498

gains 1 mark each

but Total = 2354 kJ
Deduct one mark for each mistake.
Answer of 1426 kJ gains 1 mark. (Candidate has ignored the 2 in front of the brackets.)

gains 2 marks

2

(iii) 2354 – 2148 = 206 kJ (Ignore any signs)
Answer is consequential on their answers to (i) and (ii).

for 1 mark

1

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(iv) exothermic because (more) heat is given out (than put it) / or
ΔH is negative /answer to (iii) is negative.).
(If the candidate gives the answer 'endothermic because heat /energy is taken in' then look back to their answers to (i) and (ii). If (i) is greater than (ii) then accept this answer.

for 1 mark

1

(b) (i) eg minimum energy for reaction
energy needed to start a reaction
energy needed to break bonds
energy needed to make two substances react
(Energy linked to starting a reaction.)

for 1 mark

1

(ii) B

for 1 mark

1

(iii) lowers activation energy / needs less energy to start reaction / less energetic route

for 1 mark

1

[9]

Q15.

(i) sulphuric acid / H_2SO_4

accept sulfuric *1 for one mark*

1

(ii) exothermic

for one mark

1

(iii) Na_2SO_4 / $(Na)_2SO_4$ / $Na_2(SO_4)$ / $(Na^+)_2SO_4^{2-}$

for one mark
lower case O(Na_2SO_4) not accepted / tops of subscripted letters should be in line or lower than lower case letters of symbols

1

[3]

Q16.

(a) (i) sulphuric acid / H_2SO_4 (accept sulfuric)

for one mark

1

(ii) Na_2SO_4 / $(Na)_2SO_4$ / $Na_2(SO_4)$ / $(Na_+)_2SO_4^{2-}$

for one mark

lower case O (Na_2So_4) not accepted/tops of subscripted numbers should be in line with or lower than lower case letters of symbols / upper case 'a' not accepted

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1

(b) (i) exothermic

for one mark

1

(ii) 60 KJ

for one mark

1

(iii) energy given out when bonds form
energy taken in when bonds break
energy given out is greater then energy taken in (owtte)

for 1 mark each

3

(iv) activation energy is low / many molecules have enough energy to react
for one mark

1

[8]

Q17.

(a) (1) + 3 → 2 + 3

accept correct multiples

1

(b) any **three** from

- to react particles must collide
- with sufficient energy
- reference to activation energy
- (to cause) bond breaking

3

(c) (i) (436 × 2) + 498

1

= 1370 (kJ)

accept (436 × 2) + 498 ***or*** *934 kJ for one mark*
allow 2 marks for 1370 if no working
or *correct working is shown*

1

(ii) calculation of bond energy or product

1

464 + 464 = 928 × 2 = 1856

incorrect calculation = 0 marks

correct deduction

allow deduction on ecf exothermic / endothermic on own
without calculation are neutral

1

[8]

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Q18.

exothermic does **not** gain any credit

1

reactants: bond breaking (436 + 242 =) 678 (kJ)

1

products: bond making (2 × 431 =) 862(kJ)

so overall 184 (kJ) released / –184(kJ)

1

[3]

Q19.

(a) increases % / amount of ammonia

1

favours the forward reaction

1

(b) reaction(s) would be too slow

1

(c) any **three** from:

- rate increased
- decreases % / amount of ammonia
- the forward reaction is exothermic
- the backward reaction is endothermic
- backward reaction favoured / forward reaction not favoured
- yield / amount of nitrogen and hydrogen increased
- the relative amount (yield) of ammonia decreases as the equilibrium is changed
- the relative amount (yield) of nitrogen and hydrogen increases as the equilibrium is changed

explanations in terms of particles are neutral

3

[6]

Q20.

(a) Bunsen (burner)

accept spirit burner do not credit candle

1

(b) blue

1

white

credit (1) if both colours correct but answers are reversed

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1

to cool the tube (B)

*accept answers which anticipate part (d) e.g. 'to condense the water vapour' or gases **or** vapours*

1

(d) (i) water

do not credit 'condensation'

1

(ii) (Water) vapour from the crystals (from tube A)

*accept steam **or** steam from tube A*

1

condenses **or** cools

accept turns to (liquid) water

1

(e) add water

gets hot **or** hotter **or** warm **or** warmer turns into solution
dissolves

or the temperature rises or there is an exothermic reaction
*accept steams **or** hisses ignore any reference to colour(s)*

2

(f) sulphuric acid

accept H_2S0_4 only if correct in every detail

1

[10]

Q21.

(a)

	bonds broken	bonds made
C – C	2 (4)	
C – H	12 (10)	
O = O	7	
C = O		8
H – O		12

1 mark for all bond breaking correct

1 mark for all bond making correct

2

(b) 1 mark for the three energy levels drawn

1

1 mark is for products and reactants labelled, with products shown lower than reactants

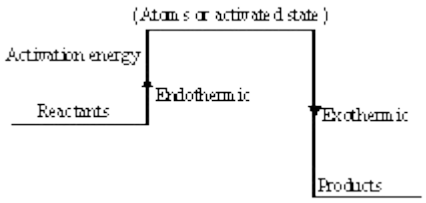
1

1 mark for activation energy in the correct position

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1

(c) 1 mark (for arrows) and endothermic exothermic labels



arrows not required

1

lowers activation energy

1

more particles have the energy to react

particles do not need as much energy to react

1

[8]

Q22.

NOTE

In this question and throughout the Paper, if the name of a chemical is asked for, then the formula is acceptable only if it is correct in every detail. If the name is correct and the candidate has tried to be 'helpful' by giving, in addition, an incorrect version of the formula, then this is acceptable provided it does not lead to ambiguity.

(i) nitric (acid)

accept $HN0_3$

1

(ii) sulphuric (acid)

accept H_2SO_4

1

(iii) heat given out

***or** temperature rise*

***or** energy given out*

***or** steam*

do not credit just 'use a thermometer'

do not credit just 'change in temperature'

1

(iv) neutralisation

accept neutralise

accept neutral

*accept formation of salt **or** water*

do not credit exothermic

1

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[4]

Q23.

(a) heat/light

1

(b) any reference to the products being (colourless) gases/smoke

1

[2]

Q24.

(a) breaking of C-H bonds
breaking of O-O bonds
making of C-O bonds
for 1 mark each

making of H-O bonds

4

(b) X energy needed to break bonds
has to be **supplied**/activation energy

Y energy released when bonds form

Z = Y-X
overall, energy is released/reaction is exothermic
each for 1 mark

5

[9]

Q25.

(i) <u>Bonds broken</u>
4 × (C – H)
2 × (O = O)
each for 1 mark

<u>Bonds formed</u>
2 × (C = O)
4 × (O – H)
each for 1 mark

4

(ii) Total energy change in breaking bonds
(4 × 413) + (2 × 498)
each gains 1 mark

<u>Total energy change in forming bonds</u>
(2 × 805) + (4 × 464)
but
to break bonds = 2648
to form bonds = 3466
each gains 2 marks

4

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(iii) nett energy transfer = 818 (kj)
this energy is released in the reaction/is an exothermic reaction
(*credit answers consistent with (ii) or derived from the initial information)*

each for 1 mark

2

[10]

Q26.

(a)

Bonds broken		Bonds formed	
number	type	number	type
3	[O=O]	4	[O–H]

each for 1 mark

2

(b) Total energy change in breaking bonds
3 × 498 = 1494

Total energy change in forming bonds
4 × 464 = 1856

each for 1 mark

Total = 3758

Total = 5076

each for 1 mark

4

(c) net energy transfer = 1318
this energy is released in the reaction/it is an exothermic reaction

each for 1 mark

[N.B. credit e.c.f. (a) → (b) and (b) → (c)]

2

[8]

Q27.

(a) fuels
heat – allow light

for 1 mark each

2

(b) gases

for 1 mark

1

[3]

Q28.

(a) (i) oxygen (not air)

(ii) oxides/monoxides/dioxides

for 1 mark each

Do not allow specific examples

2

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(b) (i) water

(ii) sulphur

(iii) carbon

for 1 mark each

3

(c) gives out/releases heat/energy

for 1 mark

1

(d) (i) carbon dioxide

(ii) carbon

for 1 mark each

(allow correct symbols/formulae)

2

[8]

Q29.

(a) nitrogen / N2

[Do not allow N or N^2] for 1 mark

(b) heat

for 1 mark

(c) carbon dioxide / CO_2

for 1 mark

[3]

Q30.

ideas that

- x = the energy required / taken in / used* to break the bonds of water / reactant [*not used up / formed]

  gains 1 mark

- **but =** the energy required taken in / used to break the bonds in water **or** activation energy

  gains 2 marks

- y = the energy released given out when bonds form

  gains 1 mark

- **but =** the energy released / given out when hydrogen / oxygen form

  gains 2 marks

- z = 1856 – 1370 or (+)486 kJ

  for 1 mark

or difference between x and y **or** net energy transferred

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- overall, energy is taken in / absorbed in the reaction
  or the reaction is endothermic **or** energy required to break existing bonds is > energy released when new bonds form

  for 1 mark

[6]

Q31.

(a) heat
light
an exothermic

in any order for 1 mark each

3

(b) oxygen / O_2

for 1 mark

1

[4]

Q32.

(a) *idea that*
existing bonds must <u>first</u> be broken

for 1 mark

(*credit* molecules / atoms more likely to react when they collide)
energy is released when new bonds form

gains 1 mark

but <u>more</u> energy is released when new bonds form

gains 2 marks

or overall reaction exothermic
this breaks more bonds so the reaction continues

for 1 mark

max 4

(b)
- reactant level higher than product level (names of reactants and products not required)
- indication that activation energy required (i.e. the “hump”)
- any correct indication of nett energy change

(i.e. between product and reactant levels even if other marks not gained)

for 1 mark each

3

[7]

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