MARKSCHEME

May 2006

CHEMISTRY

Standard Level

Paper 2

10 pages

SECTION A

1. (a) (Amount of energy required to break bonds of reactants)
$8 \times 412 + 2 \times 348 + 612 + 6 \times 496 / 7580$ (kJ mol^{-1}) ;

(Amount of energy released during bond formation)
$4 \times 2 \times 743 + 4 \times 2 \times 463 / 9648$ (kJ mol^{-1});

$\Delta H = -2068$ (kJ or kJ mol^{-1}); ***[3]***
ECF from above answers.
Correct answer scores ***[3]****.*
Award ***[2]*** *for (+)2068.*
If any other units apply ***–1(U)****, but only once per paper.*

(b) <u>exothermic</u> **and** $\Delta H^{\ominus}$ is negative / energy is released; ***[1]***
Apply ECF to sign of answer in part (a).
Do not mark if no answer to (a).

(c) $-1 \times \Delta H_1$ / 676;
$1 \times \Delta H_2$ / –394;
$2 \times \Delta H_3$ / – 484;

$\Delta H_4 = -202$ (kJ mol^{-1}); ***[4]***
Accept alternative methods.
Correct answers score ***[4]****.*
Award ***[3]*** *for (+)202 or (+)40 (kJ/kJ mol^{-1}).*
–1(U) if units incorrect (ignore if absent).

2. (a) (i) number of protons in the nucleus/atom; ***[1]***
Do not accept protons and electrons.

(ii) number of protons and neutrons in the nucleus/atom; ***[1]***

(b) $A_r(\text{Tl}) = 203 \times 0.2952 + 205 \times 0.7048 / 204.41$;
$A_r(\text{Br}) = 79 \times 0.5069 + 81 \times 0.4931 / 79.99$;
$M_r(\text{TlBr}_3) = 204.41 + 3 \times 79.99 = 444.38 / 444.37$; ***[3]***
Correct answer scores ***[3]****.*
Ignore units of g or g mol^{-1}.
Apply ECF to M_r from A_r values.

(c) Mg^{2+}; ***[1]***

(d) Al^{3+}, O^{2-}, Ne, Na^{+}, F^{-}, N^{3-}; ***[2]***
Do not accept Fl^{-}.
Award ***[2]*** *for any three,* ***[1]*** *any two.*

3. (a) $n(Cu_2O) = 10.0 \times 10^3 \div 143.1 = 69.9$ mol;
$n(Cu_2S) = 5.00 \times 10^3 \div 159.16 = 31.4$ mol;
Penalise failure to convert kg $\rightarrow$ g once only.

Cu_2S is the limiting reagent; ***[3]***
ECF from above answers.

(b) $n(Cu) = 6 \times n(Cu_2S) = 6 \times 31.4 = 188$ mol;
$m(Cu) = 188 \times 63.55 = 11900 - 12000$ g / $11.9 - 12.0$ kg; ***[2]***

If Cu_2O given in (a), allow $3 \times n(Cu_2O)$ and $3 \times n(Cu_2O) \times 63.55$.
Allow ECF from (a).

4. (a) (i) loss of electrons; ***[1]***

(ii) (a species that) gains electrons (from another species) / causes electron loss; ***[1]***

(b) changes by 3;
reduced because its oxidation number decreased / $+6 \rightarrow +3$ / $6+ \rightarrow 3+$ / it has gained electrons; ***[2]***

5. (a) same <u>general</u> formula;
successive members differ by CH_2;
Do not allow elements or just "they".
similar chemical properties;
Allow same/constant.
gradual change in physical properties;
Do not allow change periodically.
same functional group; ***[2 max]***
*Award **[1]** each for any two.*

(b) add bromine (water);
alkanes – no change / stays or turns brown;
Allow red-brown or any combination of brown, orange or yellow.
alkenes – bromine (water) decolorizes;
Do not allow clear or discoloured.

or

add (acidified) $KMnO_4$;
alkanes – no change;
alkenes – $KMnO_4$ decolorizes / brown / black; ***[3]***

SECTION B

6. (a) $K / K_c = [SO_3]^2 \div [SO_2]^2[O_2]$; ***[1]***
Accept correct K_p expression.

(b) (i) vanadium(V) oxide / (di)vanadium pentaoxide / V_2O_5; ***[1]***
Allow just vanadium oxide but not correct formula.

(ii) catalyst does not affect the value of K_c;
forward and reverse rates increase equally/by the same factor;
catalyst increases the rate of the reaction;
(by providing an alternative path for the reaction with) lower activation energy;
[4]

(c) more energetic collisions / more molecules have energy greater than activation energy;
more frequent collisions; ***[2]***
Do not accept more collisions without reference to time.

(d) (i) shifts equilibrium position to the products/right;
to the side with fewer gas molecules or moles / lower volume of gas; ***[2]***

(ii) shifts equilibrium position to the products/right;
to compensate for loss of SO_3 / produce more SO_3; ***[2]***

(iii) no effect;
forward and backward rates increased equally / by the same factor; ***[2]***

(e) exothermic;
K_c decreases with increasing temperature / back reaction favoured / heat used up / *OWTTE*; ***[2]***

(f) (i) standard free energy change (of a reaction); ***[1]***

(ii) (reaction is) spontaneous / spontaneity of the reaction; ***[1]***

(iii) spontaneity would decrease;
$-T\Delta S^{\ominus}$ becomes more positive and $\Delta G^{\ominus}$ becomes less negative/more positive / *OWTTE*; ***[2]***

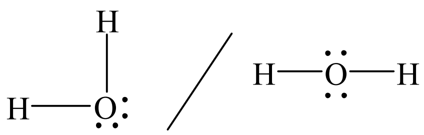
7. (a) (i) electron removed from higher energy level / further from nucleus / greater atomic radius;
increased repulsion by extra inner shell electrons / increased shielding effect; ***[2]***

(ii) Mg has twice as many / more delocalized electrons (compared to Na);
the ionic charge is twice as big / greater in Mg (than Na);
(electrostatic) attraction between ions and electrons is much greater; ***[3]***

(b) oxides of Na, Mg are basic
Al is amphoteric
Si, P, S and Cl are acidic
*Award 7 correct **[3]**, 6/5 correct **[2]** and 4/3 correct **[1]**.*

$SO_2 + H_2O \rightarrow H_2SO_3$ / $SO_3 + H_2O \rightarrow H_2SO_4$ /
$P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$ / $P_4O_6 + 6H_2O \rightarrow 4H_3PO_3$;
$Na_2O + H_2O \rightarrow 2NaOH$ / $MgO + H_2O \rightarrow Mg(OH)_2$; ***[5]***
Accept equation using P_2O_3 or P_2O_5.

(c) (i)



Allow a combination of dots, crosses or lines.
bent / V shaped / angular
104.5°;
Accept answers in range 104° to 106°.

repulsion of the two non-bonding pairs of electrons forces bond angle to be smaller / non-bonding pairs repel more than bonding pairs; ***[4]***

(ii) ethanol is polar and ethane is non-polar;
ethanol forms hydrogen bonds / dipole–dipole attractions with water and ethane does not; ***[2]***

(d) butane < propanone < propanol;
butane has van der Waals' forces;
Accept vdW, dispersion or London forces or attractions between temporary dipoles.
propanone has dipole-dipole attractions;
propanol has (the stronger) H-bonding; ***[4]***

8. (a) $HCl / H_2SO_4 / HNO_3$ / any strong acid;
CH_3COOH / H_2CO_3 / any weak acid;
Measure pH – the strong acid has the lower pH;
Accept universal indicator and two correct colours.
Measure (electrical) conductivity – this is greater for the stronger acid;
Add magnesium/carbonate – more gas bubbles with the stronger acid / Mg or carbonate would disappear faster with stronger acid; ***[5]***

(b) amphoteric/amphiprotic;
as an acid: $HCO_3^- + H_2O \rightarrow H_3O^+ + CO_3^{2-} / HCO_3^- \rightarrow H^+ + CO_3^{2-}$;
as a base: $HCO_3^- + H_2O \rightarrow OH^- + H_2CO_3 / HCO_3^- + H^+ \rightarrow H_2CO_3$; *accept* $H_2O + CO_2$. ***[3]***

(c) vinegar and factor of 10^5; ***[1]***

(d) weak acid + salt of weak acid / weak acid + conjugate base.
Accept equivalent descriptions of a basic buffer.
the solution resists pH change;
Do not accept pH does not change.
when small amounts of acid or base are added; ***[3]***
Only award if previous answer correct.

(e) (i) CH_2CH_2; ***[1]***

(ii) ***[1]***

$$\begin{array}{l} \text{HOOCCHNH}_2 \\ \quad\quad\;\;\, | \\ \quad\quad\;\, \text{CH}_3 \end{array} \;;$$

Allow appropriate acyl chloride.

(iii) $H_2N(CH_2)_6NH_2$;
$HOOC(CH_2)_4COOH$; ***[2]***
Allow correct alternative.
Accept correct names as alternatives.
If correct structure and incorrect name given, award the mark.
Penalise $COOH - C$ *once only.*

(f) (addition polymers) contain $C=C / C \equiv C$;
(condensation polymers) contain two reactive/functional groups; ***[2]***

(g) methyl methanoate;
$HCOOCH_3$; ***[2]***
Accept other correct alternative.