HWA CHONG INSTITUTION
2017 C1 H2 CHEMISTRY PROMOTIONAL EXAM
SUGGESTED SOLUTIONS

Paper 2

1 (a) (i) $H_2S + NaOH \rightarrow NaSH + H_2O$

Role of H_2S: Brønsted acid
Explanation: H_2S donates a H^+
} Both correct = **[1]**

(ii) $H_2S + H_2SO_4 \rightarrow H_3S^+ + HSO_4^-$

Role of H_2S: Brønsted base
Explanation: H_2S accepts a H^+
} Both correct = **[1]**

Alternative answer:
Role of H_2S: Lewis base
Explanation: H_2S donates an electron pair
} Both correct = **[1]**

(iii) $H_2S + H_2O \rightleftharpoons H_3O^+ + SH^-$

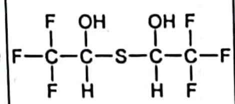
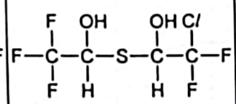
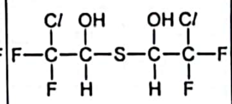
Role of H_2S: Brønsted acid
Explanation: H_2S donates a H^+
} Both correct = **[1]**

Alternative answer:
Role of H_2S: Arrhenius acid
Explanation: H_2S dissociates in water to form H_3O^+
} Both correct = **[1]**

(b) Role of H_2S: Reducing agent **[1]**

Equation: $3H_2S + 2H^+ + 2NO_3^- \rightarrow 3S + 2NO + 4H_2O$ **[1]**
ALLOW $3H_2S + 2HNO_3 \rightarrow 3S + 2NO + 4H_2O$

(c)

structure			
ratio	1	2	1

All three structures correct = **[1]**
Correct ratio (provided all three structures are correct) = **[1]**

(d) (i)
$$K_p = \frac{(P_{H_2})^2(P_{S_2})}{(P_{H_2S})^2} \quad [1]$$

(ii)

	$2H_2S$ (g) $\rightleftharpoons$	$2H_2$ (g) +	S_2 (g)
Initial amt / mol	1.0	0	0
Change / mol	−0.10	+ 0.10	+ 0.05
Eqm amt / mol	0.90	0.10	0.05

Eqm P_{H_2S} = (0.90/1.05) × 2 atm = 1.71 atm
Eqm P_{H_2} = (0.10/1.05) × 2 atm = 0.191 atm
Eqm P_{S_2} = (0.05/1.05) × 2 atm = 0.0952 atm

$K_p = (0.1905)^2(0.09524)/(1.714)^2 = 0.00118$ atm

[1] Correct eqm partial pressures of all the gases
[1] Correct K_p calculated

(iii)

	$2H_2S$ (g) $\rightleftharpoons$	$2H_2$ (g) +	S_2 (g)
Initial partial pressure / atm	1.714	0.1905	0.09524 + x
Change / atm	+0.086	−0.086	−0.043
Eqm partial pressure / atm	1.80	0.1045	0.05224 + x

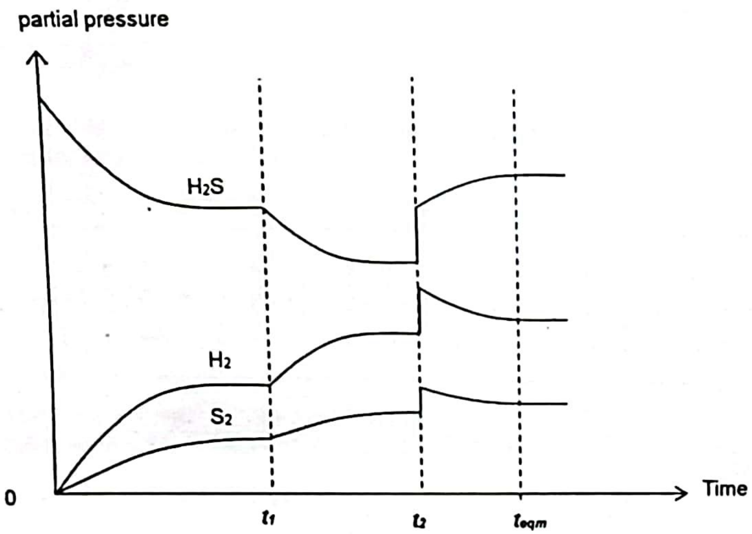
$K_p = (0.1045)^2(0.05224+x)/(1.8)^2 = 0.001176$ atm

x= 0.297 atm

[1] Correct table or equilibrium partial pressures calculated
[1] correct x value calculated

(e) (i) Temperature was increased. [1]
An increase in temperature will cause position of equilibrium to shift to the right to favour the forward endothermic reaction to absorb additional heat. [1]

(ii)



[1] Show instant increase in partial pressures of all gases at t_2

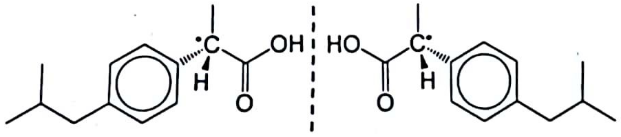
[1] Show correct changes in partial pressures after t_2

2 (a) [1] Ibuprofen is made up of simple (covalent) molecules / has simple molecular structure.

Ibuprofen is able to form strong [1/2] hydrogen bonding [1/2].
Ibuprofen has a large number of electrons [1/2], leading to a large polarisable electron cloud, hence there is significant dispersion force [1/2] as well.
Hence relatively high energy is needed to overcome these intermolecular forces.

(b) [1] Ibuprofen has a low solubility of 1.02×10^{-4} mol dm^{-3}, making it a fast acting drug.

(c)

[1] 

Mirror plane

The isomers have a chiral centre and are [1] non-superimposable mirror images of each other.

(d) (i) [1] Specific optical rotation of sample of 52° compared to specific optical rotation of pure sample of 57° shows that the **sample contains some of the other enantiomer of (+)-ibuprofen.**

[1] Enantiomer could potentially have undesirable negative health effects, and therefore the pills should not be sold.

(ii) Let x = percentage of (+)-ibuprofen
Therefore percentage of (-)-ibuprofen = 100 – x

Hence, combining the 2 given equations given in the question

e.e. = x – (100 – x) = (52 ÷ 57) x 100 = 91.2%
x = 95.6%
[2]

OR
e.e. = (52 ÷ 57) x 100 = 91.2% **[1]**
Percentage of (+)-ibuprofen = {(100 – 91.2) ÷ 2} + 91.2 = 95.6% **[1]**

(iii) Amount of (+)-ibuprofen dissolved = $\{(95.6 \div 100) \times 400 \times 10^{-3}\} \div 206$
= 0.00186 mol **[1/2]**
[(+)-ibuprofen] = (0.00186 ÷ 100) x 1000 = 0.0186 mol dm^{-3} **[1/2]**

(e) (i) [1] each
I: $KMnO_4(aq)/H_2SO_4(aq)$/heat
II: Cl_2 / $AlCl_3$

(ii) 1 [1]

(iii) 5 [1]

3 (a) (i) Maximum number of moles of H_2O would be produced with both HCl and NaOH reacting completely. [1]
So maximum heat change = max no. of moles of H_2O produced × ΔH_{neut} and max heat change gives highest ΔT.

(ii) $$\Delta H_{neut} = \frac{-60 \times 4.2 \times 8.1}{\frac{24}{1000} \times 1.50} = \frac{-2041.2}{0.036} = -56.7 \text{ kJ mol}^{-1}$$

[½] for ΔT value, accept 8.0-8.2 (± half small square reading allowance)
[½] for the working 60×4.2×8.1
[1] for division by $(\frac{24}{1000} \times 1.50)$ or division by 0.036 mol
[1] for calculated ΔH_{neut} value with – sign

(b) Draw intersection at the same volume of acid but (slightly) lower ΔT [1]

(c) No. of moles of NaOH reacted
$= \frac{60 - 18.50}{1000} \times 1.00$
= 0.0415
= No. of moles of HX reacted

$[HX] = \frac{0.0415}{18.50 \div 1000} = 2.24 \text{ mol dm}^{-3}$ [1]

(d) [½] each :

- ✓ separate measuring cylinders for the two solutions (or separate burettes but must measure into another container first e.g. polystyrene cup).
- ✓ thermometer to measure temperatures
- ✓ polystyrene cup as the reaction container
- ✓ suggest the volume of FA 1 and of NaOH to obtain at least three data points for each line

e.g.

Volume of NaOH /cm³	Volume of FA 1 /cm³
50	10
45	15
40	20
30	30
20	40
10	50

- ✓ stir after mixing
- ✓ for each mixing, measure initial temperature (for at least one solution) AND highest temperature after mixing

Suggested experimental procedure:

1. Use a burette to measure 50.00 cm³ of NaOH into a polystyrene cup. Use a thermometer to measure and record its initial temperature.
2. Use a second burette to measure 10.00 cm³ of FA 1 into a second polystyrene cup.
3. Pour the contents of the second cup into the first cup. Use the thermometer to (gently) stir the mixture and record the highest temperature reached.
4. Repeat Steps 1 to 3 using the volume combinations listed below.

Mixture	Volume of NaOH /cm³	Volume of FA 1 /cm³	Initial temperature of NaOH /°C	Highest temperature after mixing /°C	ΔT /°C
1	50.00	10.00			
2	45.00	15.00			
3	40.00	20.00			
4	30.00	30.00			
5	20.00	40.00			
6	10.00	50.00			