# Solutions to Paper 2



- $\Delta H(soln) = -LE + \sum \Delta n H(hyd) [1/2]$
- Size of cations increases down Group II, heat of hydration of cation less exothermic [1/2]

Most students can score these two marks. The students who drew an increasing line above the x-axis were awarded one upon two.

#### Common mistakes

- It is clearly stated in the question that all of the heats of solution are exothermic. Many students did not seem to notice that, judging from their answers. Their lines were above the x-axis.
- · It is  $\sum n\Delta H(hyd)$ , not just  $n\Delta H(hyd)!$
- A lot of students, while getting the full credit for the graph, failed to include the equation in their explanation.
- (b) The group I hydroxides are all hygroscopic. [1/2] Weigh the solid out promptly so as to minimise its exposure to air. [1/2]
- (c) Wear gloves. [1/2] The chemicals are corrosive. [1/2]

#### Common mistakes

- Toxicity is not the same as corrosiveness!
- Grammar! A pair of gloves, not just a glove! If you were to use just one glove, won't your other hand get corroded? A pair of googles, not just a goggle! If you were to use just one goggle, how are you going to wear it? Hold it over your eye?

### (d) <u>Procedure</u>

Major points [1/2 each, maximum 2]

- **Measure** the <u>initial temperature of the temperature</u> of the water.
- **Measure** the highest/maximum temperature reached. (No marks if temperature is lowest/minimum; ECF according to answer to (a)).
- · Measuring cylinder to measure out the water.
- Weigh mass of the residue and weighing bottle after adding the LiOH into the cup.

Minor points [1/2 each, maximum 1]

- Weigh out LiOH using a weighing bottle.
- · Cup to be supported with a beaker.
- **Repeat** the experiment until two values are within 5 % of each other. 'm' has to be specified as the mass of the *solid*.

#### Preliminary calculations [1]

Justify mass of LiOH weighed out. [NOTE: The capacity of the cup <u>must</u> be stated, otherwise at most half a mark will be awarded.] [Set  $3 \degree C \le \Delta T \le 10 \degree C$ ]  $\frac{3mc}{\Delta H} \le n \le \frac{10mc}{\Delta H}$  where m is between 50 to 90 % of the stated capacity of cup. Simplifying,  $6.14 \times 10^{-4} m \le amount \ of \ LiOH \le 2.05 \times 10^{-3} m$ If the capacity of the cup is 100 cm<sup>3</sup> and filling 90 % of it, then  $1.32 \ g \le mass \ of \ LiOH \le 4.40 \ g$ 

(e) Volumes of the two solutions are the same/same setup/same apparatus [1]

- $\begin{array}{l} \cdot \quad 3 \ ^{\circ}\mathrm{C} \leq \Delta T \leq 10 \ ^{\circ}\mathrm{C} \ \text{for both experiments.} \\ (\text{Check: } \Delta T_{1} = \frac{57.3 C_{1} V_{1}}{4.3 (30 + V_{1})} = \frac{13.3 C_{1} V_{1}}{30 + V_{1}} \ \text{and} \ \Delta T_{2} = \frac{2 \times 57.3 C_{2} V_{2}}{4.3 (30 + V_{2})} = \frac{26.7 C_{2} V_{2}}{30 + V_{2}}) \end{array}$
- no. of moles of  $H_2SO_4$  half that of  $CH_3COOH$ .
- total volume not more than 90% of capacity of cup and not less than 50% of capacity of cup.
- acids are the limiting reagents i.e.  $C_1V_1 < 60$  and  $C_2V_2 < 30$ .

2 (a)(i) 
$$n(O_2) = \frac{1}{4}n(S_2O_3^{2-}) = \frac{1}{4}(\frac{18.60\times0.001}{1000}) = 4.65 \times 10^{-6} [2]$$
  
 $[O_2] = (4.65 \times 10^{-6}) \times \frac{1000}{20} = 2.325 \times 10^{-4} \text{ moldm}^{-3} [1/2]$   
 $[O_2] = (2.325 \times 10^{-4}) \times 32000 = 7.44 \text{ mgdm}^{-3} [1/2]$ 

(a)(ii) The carps will be able to survive. (Justification).



3(a) Copper, brass and bronze all have metallic bonds. Copper is a pure metal made up of  $\underline{Cu^{2+} \text{ ions}}$ (0.069nm) arranged in a orderly metallic lattice. Brass and bronze are alloys and the presence of metal ions of different sizes disrupts the orderly metallic lattice. Ionic radius of  $Sn^{2+}$  ion (0.112nm) is bigger than ionic radius of  $Zn^{2+}$  ions (0.074nm) and the bigger ions  $Sn^{2+}$  will disrupt the orderly metallic lattice more significantly. The greater extent of disruption of the orderly lattice makes it more difficult for the layers of atoms to slide over each other, leading to greater hardness.

## Or

Copper gives out 1 electron to the sea of electron, zinc gives out 2 while tin gives out 4. <u>lonic radius of</u> <u>Cu<sup>+</sup> is approximately 0.069nm</u>, <u>Zn<sup>2+</sup> is 0.074nm and Sn<sup>4+</sup> is approximately 0.112nm</u>. <u>Charge/size of</u> <u>Cu<sup>+</sup> is lowest</u>, followed by <u>Zn<sup>2+</sup></u> and <u>Sn<sup>4+</sup></u>. The metallic bond is weakest in Cu followed by Zn and Sn. Therefore, greater force is needed for the layers of atom to slide over each other in Brass and bronze.

3(b) Zinc does not form any ions that have partially filled 3d orbital.

3(c) (i) Type of reaction: Disproportionation

 $Cu^+ \longrightarrow Cu^{2+} + e$  $E^\circ ox = -0.15V$  $Cu^+ + e \longrightarrow Cu$  $E^\circ red = +0.52V$ 

 $E^{\circ}$ cell = +0.52-0.15 = 0.37V > 0, reaction is feasible.

### NJC H2 Chemistry Prelim Solutions

(ii) **F**: [Cu(RNH<sub>2</sub>)<sub>4</sub>]<sup>2+</sup> **G**: [CuCl<sub>4</sub>]<sup>2-</sup>

(iii)  $[CuCl_4]^{2-} + 6H_2O = [Cu(H_2O)_6]^{2+} + 4Cl^{-}$ 

(iv) Cream precipitate in brown solution.

 $2Cu^{2+} + 4l^{-} \longrightarrow 2Cul + l_2$ 

(v) Cu<sup>2+</sup> has partially filled 3d orbitals. When ligands approach, the 3d orbitals of Cu<sup>2+</sup> are splitted into 2 different energy levels. When an electron is promoted from lower energy 3d orbital to higher energy 3d orbital, an energy corresponding to the wavelength in the visible region is absorbed. The complementary colour of the wavelength absorbed is blue.

(d) When copper is exposed to air, it is oxidized to CuO. When CuO reacts with the moisture in the air,  $Cu(OH)_2$  is formed. Some of the  $Cu(OH)_2$  reacts with  $CO_2$  in the air to form  $CuCO_3$ . This leads to the formation of  $Cu(OH)_2$ .CuCO<sub>3</sub>.

or

When copper is exposed to air, it is oxidized to CuO. Some of the CuO reacts with the moisture in the air forming  $Cu(OH)_2$  while some of the CuO reacts with  $CO_2$  in the air forming  $CuCO_3$ . This leads to the formation of  $Cu(OH)_2$ .CuCO<sub>3</sub>.

4(a) (i) E2:  $-O_2CCH_2CH(NH_3+)CO_2^-$  E3:  $-O_2CCH_2CH(NH_2)CO_2^-$ 

(ii) pKa<sub>1</sub> = 2.11

 $Ka_1 = 10^{-2.11} = 7.76 \times 10^{-3}$ 

(iii) E1: The solution present at E1 can act as <u>a buffer</u> and the pH change is relatively small when small amount of NaOH(aq) is added.

E3: The solution present at E3 is <u>a salt</u> and when small amount of NaOH(aq) is added, there is a large increase in pH due to  $OH^-$  from NaOH.

Or

E1: At E1, the <u>species still have H<sup>+</sup> available to neutralize OH<sup>-</sup></u>, however, at E3, the <u>species present</u> <u>does not have any H<sup>+</sup> to neutralize OH<sup>-</sup> from NaOH</u>, hence, the large increase in pH is due to the OH<sup>-</sup> from NaOH.

(iv) the two species present are HO<sub>2</sub>CCH<sub>2</sub>CH(NH<sub>3</sub><sup>+</sup>)CO<sub>2</sub><sup>-</sup> and <sup>-</sup>O<sub>2</sub>CCH<sub>2</sub>CH(NH<sub>3</sub><sup>+</sup>)CO<sub>2</sub><sup>-</sup> Salt: <sup>-</sup>O<sub>2</sub>CCH<sub>2</sub>CH(NH<sub>3</sub><sup>+</sup>)CO<sub>2</sub><sup>-</sup> Acid: HO<sub>2</sub>CCH<sub>2</sub>CH(NH<sub>3</sub><sup>+</sup>)CO<sub>2</sub><sup>-</sup>  $pH = pKa - lg(\frac{[salt]}{[acid]})$  $4 = 3.86 - lg(\frac{[salt]}{[acid]})$  $\frac{[salt]}{[acid]}) = 1.38$ 

(b) (i) Active site

(ii) When pH is low, the concentration of H<sup>+</sup> from the solution is high,  $-COO^-$  of asp will be protonated to form -COOH. Therefore, no lone pair is available to abstract H<sup>+</sup> from his and subsequent electron

transfer cannot happen. The will not be -O:<sup>-</sup> on ser to act as a nucleophile to attack the  $\delta$ + C of the peptide bond to bring about hydrolysis.



Hot NaOH(aq) CH<sub>3</sub>CO<sub>2</sub>Na CH3CH2CO<sub>2</sub>Na

5(i)

3. amide

Primary amine
 Tertiary alcohol



- 6 (a) (i) Limited Br<sub>2</sub> or excess alkane and ultraviolet light/ sunlight/ heat
  - (ii) Free radical substitution [1]

Initiation

$$Br \longrightarrow Br \longrightarrow 2 Br$$

Propagation



**Termination** 

### NJC H2 Chemistry Prelim Solutions



(iii) There are 9 primary H atoms available for substitution to form 1-bromo-2-methylpropane compared to 4 secondary H atoms to form 2-bromo-2-methylpropane.By equal probability of substitution, expected ratio of 1-bromo-2-methylpropane : 2-bromo-2-methylpropane is 9 : 1

However, a tertiary radical,  $\bullet C(CH_3)_3$ , is more stable than a primary radical,  $\bullet CH_2CH(CH_3)_2$  due to the electro-donating effects of the alkyl groups. More tertiary radicals are formed, giving rise to more 2-bromo-2-methylpropane formed. Thus the observed percentages.

- (b) (i) AlBr<sub>3</sub> or FeBr<sub>3</sub> or AlCl<sub>3</sub> or FeCl<sub>3</sub>, anhydrous
  - (ii) The Lewis acid catalyst is required to <u>form a strong electrophile (CH<sub>3</sub>)<sub>2</sub>CHCH<sub>2</sub>+ [1] to react with the aromatic /resonance stabilised benzene.</u>

AlBr3 use a vacant orbital of Al to accept/extract a lone pair/ Br-. [1]

$$OR \qquad AIBr_3 + R-Br à AIBr_4 + R^+ [1]$$

- *OR* AICl<sub>3</sub> or AIBr<sub>3</sub> will dissolve in water and be hydrolysed, hence unable to act as a Lewis acid catalyst.
- (iii)



(iv)

