

JURONG PIONEER JUNIOR COLLEGE 2019 JC2 H2 CHEMISTRY (9729) Preliminary Examination Paper 2 (Suggested Answers)

- 1 (a) (i) Particles: Cu²⁺ cation Interactions: metallic bonding
 - (ii) Particles: I₂ molecule Interactions: instantaneous dipole–induced dipole interactions
 - (b) The layers of Cu²⁺ cations can slide past each other without breaking the metallic bond (or with the mobile valence electrons holding them together).
 - (c) Electrical conductivity: Mobile valence electrons available to conduct electricity in copper but no mobile charge carriers available in iodine to conduct electricity. or

Solubility in organic solvent: lodine is able to form favourable instantaneous dipole–induced dipole interactions with the organic solvent, but copper is unable to form favourable interactions with the organic solvent.

- (d) (i) Atomic mass is the weighted average of the mass of isotopes.
 - (ii) Percentage abundance of the isotopes in this sample differs from what is normally obtained.
 - or

There are more than 2 types of isotopes of copper present in the sample.



Since angle of deflection $\propto \left| \frac{\text{charge}}{\text{mass}} \right|$,

angle of deflection of $I^{\scriptscriptstyle -}$

$$= \left| \frac{\frac{-1}{127}}{\frac{+2}{63}} \right| \times (7.0^{\circ}) = \underline{1.7^{\circ}} (1 \text{ dp})$$

(f) X Cl Br I $E (X_2/X^-) / V$ +1.36 +1.07 +0.54

Since $E(X_2/X^-)$ becomes less positive down the group, it implies that the tendency of X_2 to be reduced to X^- decreases and hence, the oxidising power of X_2 decreases down the group.

(g) (i) [O]:
$$2IO_3^- + 12H^+ + 10e^- \ll I_2 + 6H_2O \times V$$

[R]: $H_2O_2 + 2H^+ + 2e^- \ll 2H_2O + 1.77 V$
 $E_{cell} = E_{red} - E_{ox}$
 $+0.57 = (+1.77) - E_{O_3^-}/I_2$
 $E_{O_3^-}/I_2 = +1.20 V$



Note the E_{cell} value on the voltmeter at first instance of cell being connected.

2 (a)
$$\Delta H_{\text{soln}} = -\text{LE} + \sum_{\text{-ve}} \Delta H_{\text{hyd}}$$

Down the group, both LE of MCO₃ and ΔH_{hyd} of M²⁺ becomes less exothermic (or more endothermic or magnitude/value of LE of MCO₃ and ΔH_{hyd} of M²⁺ decreases) since the radius of M²⁺ increases down the group.

However, the decrease in LE is less than the decrease in ΔH_{hyd} since M²⁺ is smaller than CO₃²⁻.

Hence, ΔH_{soln} becomes less exothermic and the solubility of MCO₃ decreases down the group.

(b) (i)
$$K_{sp}$$
 of SrCO₃ = [Sr²⁺][CO₃²⁻] = $(1.05 \times 10^{-5})^2 = 1.10 \times 10^{-10} \text{ mol}^2 \text{ dm}^{-6}$

(ii) For precipitation to occur, ionic product $\geq K_{sp}$. ionic product of $SrCO_3 = [Sr^{2+}]_{min}[CO_3^{2-}] \geq K_{sp}$. $[Sr^{2+}]_{min}(0.02) = 1.1 \times 10^{-10}$ minimum $[Sr^{2+}]$ to precipitate $SrCO_3 = 5.50 \times 10^{-9}$ mol dm⁻³

ionic of $SrF_2 = [Sr^{2+}]_{min}[F^-]^2 \ge K_{sp}$. $[Sr^{2+}]_{min}(0.1)^2 = 2.5 \times 10^{-9}$ minimum $[Sr^{2+}]$ to precipitate $SrF_2 = 2.50 \times 10^{-7}$ mol dm⁻³

 $SrCO_3$ will precipitate first because a lower $[Sr^{2+}]$ is required to form the precipitate.

(c) The student's response is incorrect as $SrCO_3$ has a higher decomposition temperature than $CaCO_3$.

Thermal stability of Group 2 carbonate depends on the charge density of M^{2+} , not lattice energy. Since Sr^{2+} has a larger radius, Sr^{2+} has a lower charge density than Ca^{2+} . Hence, Sr^{2+}

polarises large CO_3^{2-} less and weaken the C–O bond to a smaller extent than that in BaCO₃.

Hence, $SrCO_3$ has a higher thermal stability and has a higher decomposition temperature.

- (d) (i) Electrode A: $Pb(s) \rightarrow Pb^{2+}(aq) + 2e^{-}$ Electrode B: $Pb^{2+}(aq) + 2e^{-} \rightarrow Pb(s)$ Electrode C: $4OH^{-}(I) \rightarrow O_{2}(g) + 2H_{2}O(g/I) + 4e^{-}$
 - (ii) $X^{n+} + ne^- \rightarrow X$ n(X) deposited = 1 ÷ 119 = 0.008403 mol n_e passed = 3240 ÷ 96500 = 0.03358 mol mole ratio X : e^- 0.008403 : 0.03358 1 : 4 Hence, the value of n is 4.
- (e) Energy / kJ mol⁻¹



3 (a)

(i)	Compound B	Compound C		
	HO	CN		

 (ii) step 2 : acidified K₂Cr₂O₇(aq), heat under reflux step 4 : Al₂O₃, heat (or excess conc. H₂SO₄(I), heat) step 5 : LiA/H₄, dry ether

(iii) Type of mechanism: nucleophilic addition



average $t_{\frac{1}{2}} = \frac{1}{2} (48 + 48) = 48 \text{ min}$ Since the half-lives are constant at about 48 min, the order of reaction with respect to [C₆H₅CH(CH₃)C/] is 1.



From the graph of $[OH^-] = 1.0 \text{ mol } dm^{-3}$ Initial rate = $\left|\frac{0.02 - 0.05}{40 - 0}\right| = 7.50 \times 10^{-4} \text{ mol } dm^{-3} \text{ min}^{-1}$ From the graph of $[OH^-] = 1.0 \text{ mol } dm^{-3}$ Initial rate = $\left|\frac{0.02 - 0.05}{80 - 0}\right| = 3.75 \times 10^{-4} \text{ mol } dm^{-3} \text{ min}^{-1}$ When $[CH_3O^-]$ doubles, the rate is doubled. Hence, the order of reaction with respect to $[CH_3O^-]$ is 1.

(iii) rate =
$$k [C_6H_5CH(CH_3)Cl] [CH_3O^-]$$

units of k = $\frac{\text{mol } \text{dm}^{-3} \text{ min}^{-1}}{(\text{mol } \text{dm}^{-3})^2} = \text{mol}^{-1} \text{dm}^3 \text{min}^{-1}$

(iv) Experiment 3: $t_{\frac{1}{2}}$ of $C_6H_5CH(CH_3)Cl = \frac{\ln 2}{k(2.0)} = \frac{1}{2} \times 48 = \frac{24 \text{ min}}{24 \text{ min}}$



(a) (i) Volume of pure methanoic acid in one ant

 $= (7.5 \times 10^{-3}) \times \frac{50}{100} \times \frac{100}{80} = 4.688 \times 10^{-3} \, \text{cm}^3$

No. of ants required to produce 1 cm³ of pure methanoic acid

$$= \frac{1}{1000} \div (4.688 \times 10^{-3}) = 214$$

(ii) volume of HCOOH injected by one ant = $(7.5 \times 10^{-3}) \times \frac{50}{100} = 3.75 \times 10^{-3} \text{ dm}^3$ mass of HCOOH injected by one ant = $(3.75 \times 10^{-3}) \times 1.2 = 4.50 \times 10^{-3} \text{ g}$ no. of ants needed = $(1.8 \times 0.2) \div (4.50 \times 10^{-3}) = 80$

(iii) 2HCOOH + Na₂CO₃
$$\rightarrow$$
 2HCOONa + H₂O + CO₂

(iv) n(HCOOH) injected by one bee = $(5.4 \times 10^{-3}) \div 30.0 = 1.80 \times 10^{-4}$ mol Since $1Na_2CO_3 = 2HCOOH$, n(Na₂CO₃) required = $\frac{1}{2} \times (1.80 \times 10^{-4}) = 9.00 \times 10^{-5}$ mol Mass of Na₂CO₃ needed to neutralise one bee sting = $(9.00 \times 10^{-5}) \times 106.0 = 0.00954$ g



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(c) (i) Let compound J be $C_xH_yO_z$. $C_xH_yO_z + (x + \frac{y}{4} - \frac{z}{2})O_2 \rightarrow xCO_2 + (\frac{y}{2})H_2O$ $n(H_2O)$ collected = 0.038 ÷ 18.0 = 0.002111 mol

> After cooling: volume of gases = $V(unreacted O_2) + V(CO_2) = 140 \text{ cm}^3$

After reaction with NaOH: $V(CO_2) = 90 \text{ cm}^3$ $V(\text{unreacted } O_2) = 50 \text{ cm}^3$ $V(\text{reacted } O_2) = 150 - 50 = 100 \text{ cm}^3$ $n(CO_2) \text{ evolved} = \frac{90}{1000} \div 24.0 = 0.00380 \text{ mol}$ $n(\text{reacted } O_2) = \frac{100}{1000} \div 24.0 = 0.00417 \text{ mol}$

$C_xH_yO_z$	+	$(x+\frac{y}{4}-\frac{z}{2})O_2$	\rightarrow	xCO ₂	+	$(\frac{y}{2})H_2O$
		0.00417		0.00380		0.00211
		2		1.8		1
		10		9		5

x = 9, y = 10 and z =

Hence, the molecular formula of J is $C_9H_{10}O_3$.

- (ii) reaction 1 phenol reaction 2 carboxylic acid
- (iii) C₇H₆O₃
- (iv) –CH(CH₃)OH is present.



- (vi) To form K (*i.e.* benzoic acid and phenol), the acid used must be a stronger acid than benzoic acid and phenol (e.g. H_2SO_4 which is a strong acid). Since the K_a of CF₃CO₂H is higher than that of benzoic acid and phenol, CF₃CO₂H is a stronger acid and hence, it can be used as a replacement for sulfuric acid.
- (vii) *K*_a of ethanoic acid is higher than that of phenol,

p–p orbital overlap results in the delocalisation of lone pair on O⁻ into C=O of CH₃COO⁻, dispersing the negative charge over two electronegative O atoms and stabilises CH₃COO⁻ more than phenoxide ion. Hence, ethanoic acid is a stronger acid and has a higher K_a than phenol.

• K_a of trifluoroethanoic acid is higher than that of ethanoic acid.

The three electron–withdrawing (or electronegative) F atoms disperses the negative charge on O⁻ of CF₃COO⁻ and stabilises CF₃COO⁻ more than CH₃COO⁻. Hence, trifluoroethanoic acid is a stronger acid and has a higher K_a than ethanoic acid.