## VICTORIA JUNIOR COLLEGE 2022 JC1 PROMOTIONAL EXAM H2 CHEMISTRY PAPER 1 ANSWERS

1	С	6	Α	11	в	16	в	21	С	26	С
2	в	7	в	12	в	17	Α	22	С	27	D
3	Α	8	в	13	Α	18	D	23	в	28	D
4	Α	9	С	14	С	19	Α	24	D	29	Α
5	Α	10	Α	15	D	20	в	25	С	30	D

# 1 C (1 and 3 only)

## Option 1: Correct

Lv<sup>+</sup> has 116 - 1=115 electrons while  $Fl^-$  has 114 + 1 = 115 electrons

## **Option 2: Wrong**

Angle of deflection  $\alpha$  |charge / mass| Angle of deflection of Lv<sup>3+</sup>  $\alpha$  |+3/292| = 0.0103 Angle of deflection of Fl<sup>2-</sup>  $\alpha$  |-2/289| = 0.00692 Option 2: Correct

## **Option 3: Correct**

From the Data Booklet, Fl having 114 proton no. is in Group 14, Lv having 116 proton no. is in Group 16.

Hence, outer electronic configuration of Fl:  $ns^2np^2$ ; Lv:  $ns^2np^4$ ;  $Fl^{2-}$ :  $ns^2np^4$ 

In addition, being in the same period, they have the same number of **core electrons**, similar to that of the noble gas at the end of the previous period.

Hence, one Lv atom has the same electronic configuration as one  $Fl^{2-}$  ion.

# 2 B

Large increase between the  $2^{nd}$  and  $3^{rd}$  IE  $\Rightarrow$  element **X** is in Group 2.

Hence, **X** forms the cation  $X^{2+}$ . To maintain overall charge neutrality, the formula of compound **Y** should thus be  $XO_2$ .

# 3

The N atom in -CN group of NH<sub>2</sub>CN has a **lone pair of electrons** for **donation**, while the B atom in BF<sub>3</sub> has a **vacant orbital** to **accept the lone pair of electrons**. This will allow the **formation of dative bond** when the shared pair of electrons is provided by only N.

## 4

Α

<b>Option A: Correct</b>	
POCl <sub>3</sub> (4bp)	CCl <sub>4</sub> (4bp)
Tetrahedral	Tetrahedral
109.5°	109.5°
Option B: Wrong	
AlCl <sub>3</sub> (3bp)	NC <i>l</i> <sub>3</sub> (3bp + 1lp)
Trigonal planar	Trigonal pyramidal
120°	107°
Option C: Wrong	
SO <sub>2</sub> (2bp + 1lp)	CO <sub>2</sub> (2bp)
Bent shape	Linear
118°	180°
Option D: Wrong	

$C_lF_3$ (3bp + 2lp)	SF <sub>4</sub> (4bp + 1lp)
T-shaped	See-saw
90°	120º & 90º

# Α

5

## **Option A: Correct**

Both substances have intermolecular hydrogen bonding but the second substance has larger electron cloud size which is more easily polarised. Hence, there are stronger instantaneous dipoleinduced dipole (id-id) interactions between CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>OH molecules. Hence, the first substance has a lower bp.

## **Option B: Wrong**

I<sub>2</sub> is a solid whereas HC*l* is a gas. This indicates that I<sub>2</sub> has a higher bp. This is because I<sub>2</sub> has a much larger electron cloud size which is more easily polarised. Hence, larger amount of energy is required to overcome stronger id-id interactions between I<sub>2</sub> molecules than weaker permanent dipole-permanent dipole interactions between HC*l* molecules. Hence, the first substance has a higher bp.

## **Option C: Wrong**

Larger amount of energy is required to overcome the stronger hydrogen bonding between CH<sub>3</sub>CH<sub>2</sub>NHCH<sub>3</sub> molecules than the weaker permanent dipole-permanent dipole interactions between CH<sub>3</sub>CH<sub>2</sub>OCH<sub>3</sub> molecules. Hence, first substance has a higher boiling point.

## **Option D: Wrong**

CH<sub>3</sub>COOH exists as **dimers**, whereby two CH<sub>3</sub>COOH molecules bond to each other via intermolecular hydrogen bonds. As such, higher extent of hydrogen bonds is formed between CH<sub>3</sub>COOH molecules than that between CH<sub>3</sub>CH<sub>2</sub>OH molecules. Hence, the first substance has a higher boiling point.

## 6 A

Since silicon carbide has a high mp, it should have a giant molecular structure  $\Rightarrow$  options A or C Since it is also hard, its structure is expected to represent the tetrahedral structure of diamond rather than the layer structure of graphite  $\Rightarrow$ option A

## 7 B

Let the percentage yield for each step be y%. For first step: Theoretical n<sub>Na2CO3</sub> produced from Na<sub>2</sub>S

= n<sub>Na2s</sub> reacted

 $= (50 \times 1000) / 78.1 = 640 \text{ mol}$ 

Actual  $n_{Na2CO3}$  produced = y% x 640

= (y / 100) x 640

For second step: Theoretical  $n_{NaHCO3}$  produced from  $Na_2CO_3$ = 2 x  $n_{Na2CO3}$  reacted = 2 x 6.40y = 12.8y mol Actual  $n_{NaHCO3}$  produced = y% x 12.8y=  $(y / 100) \times 12.8y$ =  $0.128y^2$  mol Hence, mass of  $NaHCO_3 = 20.5 \times 1000$ =  $0.128y^2 \times 84.0$ y = 43.7% 8 B  $C_4H_{10} + 13/2O_2 \rightarrow 4CO_2 + 5H_2O$ 3/4w (13/2)(3/4)w

 $C_4H_{10} + 9/2O_2 \rightarrow 4CO + 5H_2O$ 1/4w (9/2)(1/4)w

Vol. of 
$$O_2 = (13/2)(3/4)w + (9/2)(1/4)w$$
  
= (48/8)w  
= 6w dm<sup>3</sup>

## 9 C

Replacing all the alcohol groups bonded directly to the ring carbon atoms with chlorine gives the structure



Molecular formula of the product =  $C_6H_8Cl_4O_2$ . Dividing by 2 gives the empirical formula  $C_3H_4Cl_2O$ .

# 10 A

 $\begin{array}{l} Zn \rightarrow Zn^{2+} + 2e^{-} \\ Amt \ of \ Zn = 0.5/65.4 = 7.65 \ x \ 10^{-3} \ mol \\ Amt \ of \ e^{-} \ lost = 2 \ x \ 7.65 \ x \ 10^{-3} = 1.53 \ x \ 10^{-2} \ mol \\ = \ Amt \ of \ e^{-} \ gained \\ Amt \ of \ VO_{2}^{+} = 10.2/1000 \ x \ 0.500 \\ = 5.10 \ x \ 10^{-3} \ mol \\ \Rightarrow 1 \ mol \ VO_{2}^{+} \ will \ gain \ (1.53 \ x \ 10^{-2})/(5.10 \ x \ 10^{-3}) \\ = 3 \ mol \ e^{-} \ for \ reduction \\ \end{array}$ 

 $\Rightarrow$  O.N. of V will decrease by 3 units from +5 in VO\_2^+ to +2 in the reduced product

### 11 B



By Hess' law:

В

 $\Delta H_r = -283 + 2(-286) - (-715) = -140 \text{ kJ mol}^{-1}$ 

### 12

$$\begin{split} \Delta H_{sol} &= \Delta H_{hyd}(Mg^{2+}) + 2\Delta H_{hyd}(Cl^{-}) - LE(MgCl_2) \\ &= (-1890) + 2(-384) - (-2526) \\ &= -132 \text{ kJ mol}^{-1} \end{split}$$
 Amt of MgCl\_2 = 2.00/95.3 = 0.0210 mol Assuming 100% heat transfer, heat gained by water = heat evolved in expt = 132 × 0.0210 = 2.77 kJ = 2770 J q = mc\Delta T  $\Delta T = \frac{q}{mc} = \frac{(2770)}{(50 \times 4.18)} \\ &= +13.3 \text{ °C} \\ (exothermic reaction, \Delta T \text{ is positive}) \end{split}$ 

### 13 A (1, 2 and 3)

**Option 1: Correct** 

 $\Delta H_{rxn} = \sum \Delta H_f(products) - \sum \Delta H_f(reactants)$ 

= +2807 kJ mol<sup>-1</sup>

## **Option 2: Correct**

The process has no change in number of particles of gases. However, comparing 6 mol of H<sub>2</sub>O(I) reactant with 1 mol of C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>(s) product, the number of particles decreases and a liquid reactant is changed to a solid product with a more ordered structure. Hence, there is a decrease in overall entropy and  $\Delta S$  has a negative sign (i.e. less disordered).

### **Option 3: Correct**

Since  $\Delta G = \Delta H$  (+ve) – T $\Delta S$  (–ve), the  $\Delta G$  for the reaction will always be positive at all temperatures as  $\Delta H$  and – T $\Delta S$  is always positive.

# 14 C

Vol. of KMnO<sub>4</sub> required  $\alpha$  [H<sub>2</sub>O<sub>2</sub>] remaining Graph shows constant half-life of 14 min  $\Rightarrow$  Order of reaction wrt H<sub>2</sub>O<sub>2</sub> is 1. [H<sub>2</sub>O<sub>2</sub>] in 10cm<sup>3</sup> sample at 0 min =  $(\frac{5}{2} \times \frac{30}{1000} \times 0.05) / (10 \times 10^{-3})$ = 0.375 mol dm<sup>-3</sup>  $3.00 \xrightarrow[t_{1/2}]{} 1.50 \xrightarrow[t_{1/2}]{} 0.75 \xrightarrow[t_{1/2}]{} 0.375$ Contamination period =  $3t_{1/2} = 3 \times 14$ = 42 min

## 15 D (3 and 4 only)

From the Arrhenius equation,  $k = Ae^{-\frac{Ea}{RT}}$ , rate constant is affected only by temperature or catalyst. Hence, changing the concentration does not affect the rate constant.

 $\Rightarrow$  Option 1 wrong, Option 3 correct

The amount of kinetic energy possessed by the reactant particles is affected by temperature only. Hence, increasing the temperature increases the proportion of particles having energy greater than the activation energy but increasing the concentration has no effect.

 $\Rightarrow$  Option 2 wrong, Option 4 correct

## 16

В

Α

Based on Step II, the slow step, rate equation is rate =  $k_1 [N_2O_2][H_2]$ However,  $N_2O_2$  is an intermediate, not a reactant. Hence it will have to be re-expressed in terms of its reactants based on Step I:  $[N_2O_2] \propto [NO]^2$  $\Rightarrow [N_2O_2] = k_2 [NO]^2$ Substituting, Rate =  $k_1 k_2 [NO]^2 [H_2] = k [NO]^2 [H_2]$  (k =  $k_1 \cdot k_2$ )

## 17

Moles before opening = moles after opening  $\frac{(1 \times 10^5) \times (\mathbf{V})}{R \times (273+25)} = \frac{(\mathbf{p}) \times (4\mathbf{V})}{R \times (273+100)}$   $\mathbf{p} = 3.13 \times 10^4 \text{ Pa}$ 

#### 18 D

When pressure increases, position of equilibrium shifts right to favour the side with less number of moles of gas to reduce the pressure. Hence, more NH<sub>3</sub> is formed and yield increases.

19 A					
	$N_2O_4(g)$	11	2NO <sub>2</sub> (g)		
Initial moles	1		0.2		
Change in mole	-0.24		+0.48		
Eqm moles	0.76		0.68		
$[NO_2]^2$ (0.68 / 4) <sup>2</sup>					

$$K_c = \frac{[N_2O_4]}{[N_2O_4]} = \frac{(0.007 \text{ / })}{(0.76 \text{ / }4)} = 0.15 \text{ mol } \text{dm}^{-3}$$

#### 20 B (1 and 2 only)

A Bronsted Lowry acid donates a proton to form its conjugate base, e.g.  $HA \rightarrow H^+ + A^$ acid conjugate base **Option 1: Correct**  $H_2O \rightarrow H^+ + OH^-$ 

acid conjugate base **Option 2: Correct** 

 $H_2PO_4^- \rightarrow H^+ + HPO_4 \,{}^{2-}$ 

#### acid conjugate base

### **Option 3: Wrong**

NaH is an ionic compound containing Na<sup>+</sup> cation and  $H^-$  anion (which is not the same as  $H^+$ ). Hence, NaH is not capable of acting as a proton donor and is not an acid.

### 21

 $n_{\text{NaOH}} = \frac{20}{1000} \times 0.500 = 0.0100 \text{ mol}$  $n_{CH_3CO_2H} = \frac{20}{1000} \times 1.00 = 0.0200 \text{ mol}$ 

CH<sub>3</sub>CO<sub>2</sub>H + NaOH → CH<sub>3</sub>CO<sub>2</sub>Na + H<sub>2</sub>O  
[CH<sub>3</sub>CO<sub>2</sub>H] = 
$$\frac{0.0200 - 0.0100}{\frac{20 + 20}{1000}}$$
 = 0.250 mol dm<sup>-3</sup>  
[CH<sub>3</sub>CO<sub>2</sub>Na] =  $\frac{0.0100}{\frac{20 + 20}{1000}}$  = 0.250 mol dm<sup>-3</sup>  
pH = pK<sub>a</sub> + lg  $\frac{[CH_3CO_2Na]}{[CH_3CO_2H]}$   
= -lg(1.8×10<sup>-5</sup>) = 4.74

### 22

С

 $pK_a = 4.70 \Rightarrow K_a = 10^{-4.70}$ . Since  $K_a$  is small, **G** is a weak acid.

NaOH is a strong base.

Since the titration is between a weak acid and a strong base, the pH at the equivalence point will be in the slightly basic region (about 8 to 9) as the conjugate base of G that is formed will undergo salt hydrolysis. Hence, cresolphthalein (rather than indigo carmine) will be the most suitable indicator.

#### 23 B (1 and 2 only)

**Option 1: Correct** 

The type of hybridization undergone by each carbon is shown below:

$$sp^{2} = sp^{2} = sp^{2} = sp^{2} = sp^{2} = sp^{2} = sp^{2} = sp^{3} = sp^{2} = sp^{3}$$
  
 $CH_{2} = CH_{2} = CH_{3} = CH_{3} = CH_{3}$   
 $1 = 2 = 3 = 4 = 5$   
 $C \equiv N$   
 $sp$ 

## **Option 2: Correct**

 $\pi$  bond is always formed by the side-way overlap of p orbitals.

### **Option 3: Wrong**

C1-C2 bond is formed from sp2-sp2 overlap whereas C4-C5 bond is formed from sp2-sp3 overlap. sp<sup>2</sup> orbital has a higher degree of s character than sp<sup>3</sup> orbital and hence electrons in sp<sup>2</sup> orbital are closer to the nucleus. Bond formed from sp<sup>2</sup>-sp<sup>2</sup> is thus shorter than that formed from sp<sup>2</sup>-sp<sup>3</sup>.

#### 24 D (2 and 4 only)

Molecular formula of the compound is of the form C<sub>n</sub>H<sub>2n-2</sub>O<sub>2</sub>. Based on the C : H ratio, the compound has two pi bonds present.

## **Option 1: Can be present**

One pi bond in C=C and one pi bond in  $-CO_2H$ . **Option 2: Cannot be present** 

One pi bond in C=O but no pi bond in alcohol.

### **Option 3: Can be present**

One pi bond in ketone and one pi bond in aldehyde.

### **Option 4: Cannot be present**

One pi bond in C=C but no pi bond in alcohol.

#### 25 С



#### 26 С

3 different structures can be formed:



The 3<sup>rd</sup> structure has two chiral centres (marked with \*), giving rise to  $2^2 = 4$  stereoisomers. Hence the total number of isomers = 1 + 1 + 4 = 6

### 27

D

Observe that each propagation step lengthens the radical by introducing an additional CH<sub>2</sub>CH<sub>2</sub>O- unit. Hence the free radical formed in each propagation step will consist of n repeating units of -CH<sub>2</sub>CH<sub>2</sub>O- with the general formula •CH<sub>2</sub>CH<sub>2</sub>O(CH<sub>2</sub>CH<sub>2</sub>O)<sub>n-2</sub>CH<sub>2</sub>CH<sub>2</sub>O•. The formula of the non-ionic detergent should therefore contain either (CH<sub>2</sub>CH<sub>2</sub>O)<sub>n</sub> or (OCH<sub>2</sub>CH<sub>2</sub>)<sub>n</sub>. For D: CH<sub>3</sub>(CH<sub>2</sub>)<sub>10</sub>O(CH<sub>2</sub>CH<sub>2</sub>O)<sub>10</sub>H

The part marked with the bracket corresponds to the free radical formed in the propagation stage and the remaining parts, CH<sub>3</sub>(CH<sub>2</sub>)<sub>10</sub>O and H, when combined together, correspond to the formula of an alcohol.

For **A**, the repeating unit shown is wrong:  $[CH_3(CH_2)_{10}O]_{10}CH_2CH_2OH$ 1

Wrong repeating unit

For B and C:  $CH_3(CH_2)_{10}O(OCH_2CH_2)_{10}OH$ 

 $CH_3(CH_2)_{10}O(CH_2CH_2O)_{10}OH$ 

The parts marked with the bracket corresponds to the free radical formed in the propagation stage but the remaining parts of each formula, when combined together, do not correspond to the formula of an alcohol since there is an extra oxygen.

### 28



D



### Fragments formed are

5 4 3 2 CH<sub>3</sub>COCH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CCOCOCH<sub>2</sub>CO<sub>2</sub>H and (CH<sub>3</sub>)<sub>2</sub>CO

### 29

Α

In D, the isomer that is formed, the Br atom is attached to the carbon with more hydrogen atoms. By Markonikov's rule, this means that Br is the electrophile that attacks the alkene group in the first step to form the more stable carbocation:



Similarly, CH<sub>3</sub>CH=CHCH<sub>3</sub> is attacked by the Br electrophile to form the following intermediate:

#### D 30

X has 4 chiral centres marked with \* below:



# **Option A: Wrong**

Two -OH groups are added across the C=C group. The product formed has 5 chiral centres as shown below:



### **Option B: Wrong**

Alcohol undergoes dehydration to form two possible alkenes. Either product has 3 chiral centres:



### **Option C: Wrong**

Bromination takes place across the C=C group. Product formed has 5 chiral centres as shown below:



## **Option D: Correct**

Hydrogenation takes place across the C=C group. Product formed still has 4 chiral centres as shown below:

