# Nanyang JC J2 Preliminary Examinations 2024 H2 Chemistry 9729/01 Paper 1 MCQ Answers and Comments

Qn	Ans	A · 7										
1	D	6	В	11	В	16	D	21	D	26	С	<b>R</b> . 7
2	В	7	D	12	D	17	С	22	С	27	D	
3	D	8	С	13	С	18	С	23	Α	28	С	
4	Α	9	Α	14	D	19	Α	24	Α	29	Α	<b>D</b> . 0
5	D	10	В	15	Α	20	В	25	В	30	В	

<b>1 D</b> mod N22P1Q6	From the <i>Data Booklet</i> , we can conclude • <b>G</b> is likely to be Al
$rightarrow $ of deflection, $θ = k × \frac{\text{charge}}{\text{mass}}$ (NB: Elements <b>V</b> and <b>W</b> are not their usual	<ul> <li>H is an element below S in Group 16. (1st IE of H &lt; 1st IE of S. Down the group, 1st IE decrease.)</li> </ul>
symbol in the Periodic Table.) Both Ca and V form cations with +2 charge. Hence, since $\theta(Ca^{2+}) > \theta(V^{2+})$ , $\Rightarrow A_r(Ca) < A_r(V)$ , V must be below Ca in Group 2.	<b>H</b> : [noble gas] $ns^2 np_x^2 np_y^1 np_z^1$ Statement 1 is correct. There is only one p orbital with paired electrons in <b>H</b> .
Therefore element <b>V</b> is Sr and <b>W</b> is either Rb or Y.	<b>G</b> is Period 3, <b>H</b> is at least Period 4. Statement 2 is correct. <b>H</b> has a larger
From Ca <sup>2+</sup> , we can determine a value for k. k = 240 (or 240.6 using $A_r$ )	The factors that affect IE are i) nuclear charge (IE increase with
Using k, we can calculate the $\frac{\text{charge}}{\text{mass}}$ ratio for	increasing nuclear charge) ii) shielding effect (IE decrease with
$\mathbf{W}, \frac{1}{\text{mass}}(\mathbf{W}) = 0.0337$	increasing shielding effect) iii) distance from nucleus (IE decrease with increasing distance from nucleus)
Lastly, compare the $\frac{\text{charge}}{\text{mass}}$ ratio calculated against those of Rb <sup>+</sup> and Y <sup>3+</sup> , $\frac{\text{charge}}{\text{mass}}$ (Rb <sup>+</sup> ) = 0.0117 and	Hence the only factor that can explain why the 3rd IE of <b>H</b> is larger than 3rd IE of <b>G</b> is the nuclear charge.
$\frac{charge}{mass} (Y^{3+}) = 0.0337,$ we can deduce the identity of element <b>W</b> as Yttrium (proton number 39).	<b>H</b> is below S in Group 16 as the 1st IE of H (940) is smaller than the 1st IE of S (1000). However, as we do not have the IEs of Croup 16 elements below S we connect
<b>2 B</b> mod NY20 Promo P1Q3	positively identify which of Se, Te or Po is <b>H</b> .
Deduce the group number of elements <b>G</b> and <b>H</b> by looking at the largest jump in IEs.	the data. (FYI, <b>H</b> is Se)
<b>G</b> : largest jump at 4th IE, 4th electron is removed from inner shell, 3 valence electrons, <b>G</b> is Group 3.	(For <b>H</b> , we can eliminate Group 6 as 1st IE of Cr is < 940 kJ mol <sup>-1</sup> . Elements below Cr in Group 6 will also have 1st IE < 940.)
H: largest jump at 7th IE, 7th electron is removed from inner shell 6 valence	3 D
electrons, <b>H</b> is Group 16.	To deduce bond angles fast in MCQs, use the following shortcut.

- The number of bond pairs around the central atom is given by the number of non-central atoms in the formula
- To determine the number of lone pairs, give the charge to the central atom. Hence if charge is –, give one electron to central atom. If charge is +, take one electron away from central atom. Next, subtract the valence electrons of the central atom that are used to bond to each non-central O (need 2 electrons each) or X (need 1 electron each). Lastly pair the remaining electrons around the central atom to obtain the number of lone pairs.

A)	NO₃ <sup>−</sup>		BeCl <sub>2</sub>
BP-LP	3 – 0		2 – 0
bond angle	120°	<	180°
B)	BrO₃⁻		PCI <sub>4</sub> +
, BP-LP	3 – 1		4 - 0
bond angle	107°	<	109°
C)	AsF6 <sup>−</sup>		XeF₄
BP-LP	6 – 0		4 – 2
bond angle	90°	=	90°
D)	SO <sub>2</sub>		SO4 <sup>2-</sup>
, BP-LP	2 – 1		4 - 0
bond angle	118°	>	109°

## **4 A** mod N21P1Q5

#### Shapes of hybrid orbitals

sp	sp <sup>2</sup>	sp <sup>3</sup>
$\bigotimes$	$\left\{ \right\}$	$\bigcirc$
50% s		75% p
character.		character.
more		more
spherical		elongated
shortest		longest
bondlength		bondlength
strongest		weakest bond
bond		

## 5 D

In explaining solubility, we compare

- Energy required to break bonds between solute particles and bonds between solvent particles
- Energy evolved when bonds are formed between solute and solvent particles

The most extensive/dominant bonds formed between water and hexanol molecules (due to the long alkyl chain of hexanol) is the instantaneous dipole – induced dipole interactions between hexanol alkyl chains and water molecules.

Therefore, water and hexanol do not mixed because the energy evolved when id-id interactions formed between water and hexanol is not sufficient to compensate for the energy required to break hydrogen bonding in water molecules.

## 6 B

A. Na<sub>2</sub>O(s) dissolve in water to form NaOH(aq). Since dilute NaOH(aq) is not saturated, Na<sub>2</sub>O can still dissolve.

B. MgO is an ionic oxide that is basic. It will not react with alkaline NaOH(aq). MgO is also insoluble, giving only a weakly alkaline solution of pH 9 with water.

C. Al<sub>2</sub>O<sub>3</sub> is an ionic oxide with high covalent character. It is amphoteric and will dissolve in NaOH(aq) to form a soluble complex NaAl(OH)<sub>4</sub>.

D.  $P_4O_{10}$  is a covalent oxide that is acidic. It reacts with NaOH(aq) to form a soluble salt Na<sub>3</sub>PO<sub>4</sub>(aq).

#### 7 D

**Down Group 2, cationic radius increase** while cationic charge is constant. Charge density increases, polarising power becomes stronger.  $CO_3^{2-}$  electron cloud is less polarised. C-O bond in  $CO_3^{2-}$  is weakened to a smaller extent, more energy is required to break the C-O bond. Thermal decomposition temperature increase.

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8 C
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 $Cl_2(aq) + 2I^-(aq) \rightarrow l_2(aq) + 2CI^-(aq)$ 

(2)

 $Cl_2$ , stronger oxidising agent, will oxidise I<sup>-</sup> to iodine.

A. False.  $I_2$  is purple in non-polar organic hexane solvent.

B. False.  $I_2$  is a non-polar molecule with very low solubility in water. The equilibrium(2) lies almost completely to the product side.

C. Correct. Down Group 17, incoming electron added to valence shell further away from nucleus. Hence attraction of Cl nucleus to incoming electron is stronger.

D. False. I– is a **stronger reducing agent** since its valence electrons are less readily attracted to the nucleus.

#### 9 A

	nReO₄⁻	:	ne⁻	:	nZn
amt(mol)	0.008				0.0319
OA:RA ratio	1				4
Zn : e⁻			2		1
LCM Zn	1		8		4
Change in OS = Final OS – Initial OS					

-8 = Final OS - (+7) Final OS = -1

# 10 C

A is wrong. 2 mol of water is formed in the equation.

B is correct. Both Na(s) and  $O_2(g)$  are in their elemental states.

C is wrong.  $\Delta H_{hyd}$  is for gas ion to aq ion.

D is wrong. Equation given is -LE. LE is defined for ionic solid formed from constituent ions.

# **11 B** mod N21P1Q11

 $\Delta S < 0$  as there are less number of gas particles in the product. Less ways of arranging gas particles in system. Entropy of product decrease.

Using  $\Delta G = \Delta H - T\Delta S$ , as  $T\downarrow$ ,  $|T\Delta S| < |\Delta H|$  such that  $\Delta G$  becomes more negative. Hence reaction is more spontaneous when temperature decrease. Use the equation,  $[Rn]_{t} = [Rn]_{0} \times (\frac{1}{2})^{n}$   $[Rn]_{0} = \text{initial conc, } [Rn]_{t} = \text{conc at any point}$ in time, n = number of half-lives.  $0.4 = 15 \times (\frac{1}{2})^{n}$  n = 5.228time taken = 5.228 × 3.82 = 19.97 days

#### 13 C

1 is wrong. Use of a catalyst does not affect relative rates of forward and backward reactions. Both rates increase to the same extent. No change in position of equilibrium. 2 is correct. A medium high temperature of 500 °C (774 K) is used. Low temperatures 227 °C (500 K), although favouring the forward exothermic reaction to produce heat, results in a low rate of reaction, hence are not used.

3 is correct. A high pressure of  $2.03 \times 10^7$  Pa (200 atm) is used to shift the eqm position to the right by reducing total number of gas particles.

# 14 D

Analysis of the graph shows:

• V<sub>NaOH</sub> required to reached second equivalence volume is larger than V<sub>NaOH</sub> required for first equivalence volume.

 $\Rightarrow$  initial solution is already a buffer solution containing both HO<sub>2</sub>CCH<sub>2</sub>CO<sub>2</sub>H and HO<sub>2</sub>CCH<sub>2</sub>CO<sub>2</sub><sup>-</sup>.

If initial solution contains only  $HO_2CCH_2CO_2H$ ,  $V_{NaOH}$  required for each step of the neutralisation would be the same.

•  $V_{NaOH}$  required for 1st neutralisation (HO<sub>2</sub>CCH<sub>2</sub>CO<sub>2</sub>H + OH<sup>-</sup>  $\rightarrow$  HO<sub>2</sub>CCH<sub>2</sub>CO<sub>2</sub><sup>-</sup> + H<sub>2</sub>O) = 10 cm<sup>3</sup>

 $V_{NaOH}$  required for 2nd neutralisation (HO<sub>2</sub>CCH<sub>2</sub>CO<sup>-</sup> + OH<sup>-</sup>  $\rightarrow$  <sup>-</sup>O<sub>2</sub>CCH<sub>2</sub>CO<sub>2</sub><sup>-</sup> + H<sub>2</sub>O) = 34 - 10 = 24 cm<sup>3</sup>

Hence,  $V_{\text{NaOH}}$  required for neutralising only the original  $HO_2CCH_2CO^-$ 

 $= 24 - 10 = 14 \text{ cm}^3 (>10 \text{ cm}^3)$ 

 $\Rightarrow$  in the initial solution,

 $[HO_2CCH_2CO_2H] < [HO_2CCH_2CO_2^-].$ When  $[HO_2CCH_2CO_2H] = [HO_2CCH_2CO_2^-],$ solution is at maximum buffer capacity,

#### $pH = pK_{a1} = 2.85$ .

Therefore when  $[HO_2CCH_2CO_2^-] > [HO_2CCH_2CO_2H]$ , pH > p $K_{a1}$ . (i.e. we have more of the weak base component, solution is more alkaline than the mid-point) The only answer with pH > 2.85 is 3.00.

#### 15 A

Let x mol dm <sup>-:</sup>	<sup>3</sup> be the	solubility	of the salt.
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A	[CO <sub>3</sub> <sup>2-</sup> ]	$  x = \sqrt{3.5 \times 10^{-8}} $ = 1.87 x 10 <sup>-4</sup>
	рН	$14 + \lg\sqrt{2.1 \times 10^{-4} \times 1.87 \times 10^{-4}} = 10.3$
D	[CO <sub>3</sub> <sup>2-</sup> ]	$  x = \sqrt{1.8 \times 10^{-11}} $ = 4.24 x 10 <sup>-6</sup>
D	рН	$14 + \lg\sqrt{2.1 \times 10^{-4} \times 4.24 \times 10^{-6}} = 9.47$
С	[OH⁻]	$x = \sqrt[3]{\frac{2.0 \times 10^{-15}}{4}}$ 2x = 1.59 x 10 <sup>-5</sup>
	рН	14 + lg 1.59 x 10 <sup>-5</sup> = 9.20
D	[OH⁻]	$x = \sqrt[4]{\frac{8.0 \times 10^{-31}}{27}}$ 3x = 3.94 x 10 <sup>-8</sup>
	рН	14 + lg (1 x 10 <sup>-7</sup> + 3.94 x 10 <sup>-8</sup> ) = 7.14

## 16 D

All N and X atoms bonded to  $sp^2$  carbon have a lone pair in a p orbital that overlaps with p orbitals of the  $sp^2$  carbon. The lone pair will be delocalised to form  $\pi$  electrons.



# 17 C

Stability of alkyl radicals:  $3^{\circ} > 2^{\circ} > 1^{\circ}$ More electron donating alkyl groups will increase electron density on the electron deficient C radical.

The four possible product radicals of 2methylbutane





N undergoes elimination with NaOH, ethanol, heat to form a benzene ring in  $\mathbf{P}$  that does not decolourise Br<sub>2</sub>(aq).

Statement 1 is wrong as benzene ring in P does not undergo electrophilic addition in order to maintain the resonance stabilization energy of the conjugated  $6\pi$  electrons system.

Statement 2 is correct.

Statement 3 is correct. P undergoes aryl sidechain oxidation to produce 2 mol of CO<sub>2</sub>.



#### 19 A

Statement 1 is correct. An H with its bond pair constitute a  $H^-$  ion.

Statement 2 is correct. The product is a  $3^{\circ}$  carbocation that is more stable than the  $2^{\circ}$  carbocation reactant. More electron donating alkyl groups bonded to the C<sup>+</sup> will increase electron density and disperse the positive charge.

Statement 3 is correct. Step 2 must be faster than step 3. If step 2 is slower, the 2° carbocation product of step 1 will react with water in a reaction similar to step 3 to form the minor product. However, the major product in this reaction was formed from the reaction of step 2, implying that the carbocation product of step 1 immediately undergo H<sup>-</sup> rearrangement (step 2) before water can react with the carbocation (step 3).

## 20 B

There are two IUPAC rules tested for.

- The parent functional group is always assigned the smallest number in the carbon chain.
- Alkyl substituents are written in alphabetical order.



Carbon with –OH is assigned as carbon1. 5-methyl is written before 2-(propan-2-yl).

21 D mod N22P2Q5civ

In nucleophilic addition (NA) reactions, a neutral nucleophile H–Nu is added across the C=O double bond.

The diagram below shows how to identify the product of an aldol addition (NA).





#### 23 A



## **24 A** mod N22P1Q3

Statement 1 is correct.  $CH_3CH_2-O^-$  is an electron donating group that increase the electron density on the  $-O^-$ , intensifying the negative, hence  $CH_3CH_2O^-$  is not stable. Hence  $CH_3CH_2OH$  is not acidic.

Statement 2 is correct. In  $CH_3COS^-$ , S is  $sp^2$  hybridised with a lone pair in p orbital overlapping with p orbitals of C=O. Hence, negative charge on  $CH_3COS^-$  is dispersed.



Statement 3 is correct. S-H bond is weaker than O-H, less energy required to break.

Hence  $CH_3CH_2SH$  is a stronger acid than  $CH_3CH_2OH$ .

## 25 B

#### From Data Booklet,

G	–alkyl –OH or –OR –NH <sub>2</sub> , –NHR or –NR <sub>2</sub> –NHCOR	—С <i>l</i> , —Вг, —І
Reactivity of ring (compared to benzene)	Activated	Deactivated
Position of E (relative to position of G)	2- and/or 4-	2- and/or 4-

-NHCO- is an electron donating group that is 2,4-directing. The four isomer, B, is formed at higher yield. An attacking electrophile at the 2-position face stronger steric hindrance, hence electrophile attacking at 4-position forms the major product.

C is wrong as -CONH- is an electron withdrawing group that will deactivates the ring towards electrophilic attack. D is wrong as an amide functional group is not basic.

# 26 C

Dominant forms of histidine at respective pH is shown.

А	В		
pH 1.00	pH 5.20		
$H_{3}N^{+}$ $C$ $CO_{2}H$ $CH_{2}$ $HN^{+}$ $HN^{+}$	$H_{3}N^{+}$ $C_{-}CO_{2}^{-}$ $CO_{2}^{-}$ $H_{N}^{+}$ $H_{N}^{+}$ $H_{N}^{+}$		
The α-carbon bonded to COOH is bonded to four different group, hence it is chiral.	When OH <sup>-</sup> is added, it will react with and be removed by the structure shown above. pH will remain relatively constant		



- all main chain amide groups are hydrolysed
- any side chain ester or amide groups are hydrolysed



Counting anti-clockwise from pro, (or you can just name the amino acids as I, II, III etc)

pro (I)	1
phe (II)	2
asp (III)	3
gly (IV)	1
ala (V)	4
glu (VI)	1
total	12

#### 28 C

 $\begin{array}{ll} V^{3+} + e^- \rightarrow V^{2+} & E^{\Theta}(V^{3+}/V^{2+}) = -0.26V \\ Cu^{2+} + 2e^- \rightarrow Cu & E^{\Theta}(Cu^{2+}/Cu) = +0.34V \\ \text{2024 NYJC H2 Chem P1 (Ans)} \end{array}$ 

For  $E^{\Theta}$ cell = +0.60V,  $E^{\Theta}$ (Cu<sup>2+</sup>/Cu) -  $E^{\Theta}$ (V<sup>3+</sup>/V<sup>2+</sup>) = +0.34 - (-0.26) = +0.60V.

Hence  $E^{\Theta}(Cu^{2+}/Cu)$  is the cathode and  $E^{\Theta}(V^{3+}/V^{2+})$  the anode.

 $E^{\Theta}$ cell =  $E^{\Theta}$ (Cu<sup>2+</sup>/Cu) -  $E^{\Theta}$ (V<sup>3+</sup>/V<sup>2+</sup>) To increase  $E^{\Theta}$ cell, we need

- $E^{\Theta}(Cu^{2+}/Cu)$  to become more positive, or
- $E^{\Theta}(V^{3+}/V^{2+})$  to become more negative.

 $E(V^{3+}/V^{2+})$  will become more negative when POE shift left, either  $[V^{3+}(aq)]$  decrease or  $[V^{2+}(aq)]$  increase.

Hence neither A nor B is correct.

 $E(Cu^{2+}/Cu)$  will become more positive when POE shift right, i.e. when  $[Cu^{2+}(aq)]$  increase. Hence C is correct.

Increasing the surface area of Cu electrode does not change the position of equilibrium of the  $Cu^{2+}/Cu$  half-cell.

#### 29 A

At anode,  $E^{\Theta}(S_2O_8^{2^-}/SO_4^{2^-}) +2.01V$   $E^{\Theta}(O_2/H_2O) +1.23V$ Since  $E^{\Theta}(O_2/H_2O)$  is less positive than  $E^{\Theta}(S_2O_8^{2^-}/SO_4^{2^-})$ , water is oxidised to oxygen gas.

Using Q=It and Q=n<sub>e</sub>F, and the equation,

$$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$$

V<sub>02</sub> = (0.8 x 81 x 60 x 24000) / (96500 x 4) = 242 cm<sup>3</sup> (3sf) Statement 1 is correct.

At cathode,  $E^{\Theta}(Na^{+}/Na) -2.71V$   $E^{\Theta}(H_2O/H_2) -0.83V$ Since  $E^{\Theta}(H_2O/H_2)$  is less negative than  $E^{\Theta}(Na^{+}/Na)$ , water is reduced to hydrogen gas. The equation for the reaction is

$$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$$

Electrolyte turns alkaline (blue) at the cathode. Statement 2 is correct.

 $E^{\Theta}$ cell =  $E^{\Theta}$ (red) -  $E^{\Theta}$ (oxd)

$$= E^{\Theta}(H_2O/H_2) - E^{\Theta}(O_2/H_2O)$$
  
= -0.83 - (+1.23)  
= -2.06V

E<sup>o</sup>cell for the reaction is negative, hence not spontaneous. To run the reaction, electricity with a voltage of at least 2.06V is required. Statement 3 is correct.

mod N21P2Q6ai

J	white ppt with AgNO₃(aq)	free Cl⁻ as anion in ionic lattice		
	no ppt with Ba(NO <sub>3</sub> )₂(aq)	SO <sub>4</sub> <sup>2-</sup> as bound ligand in Cr(III)-complex		
к	no ppt with AgNO₃(aq)	Cl <sup>-</sup> as bound ligand in Cr(III)-complex		
	white ppt with Ba(NO <sub>3</sub> ) <sub>2</sub> (aq)	free SO <sub>4</sub> <sup>2-</sup> as anion in ionic lattice		

J is  $[Cr(NH_3)_5(SO_4)]^+$ . Statement 1 is correct. **K** is  $[Cr(NH_3)_5CI]^{2+}$ . Statement 2 is wrong.

30 B