Nanyang JC J2 Preliminary Exam 2018
H2 Chemistry 9729/01
Paper 1 MCQ Answers and Comments

Qn	Ans	Qn	Ans	Qn	Ans	Qn	Ans	Qn	Ans	Qn	Ans
1	C	6	C	11	B	16	D	21	D	26	C
2	D	7	C	12	A	17	A	22	C	27	A
3	C	8	D	13	C	18	B	23	B	28	A
4	A	9	B	14	C	19	C	24	D	29	C
5	D	10	C	15	A	20	D	25	B	30	A

1 C

A: 2 mol of NO_2 gives 4 mol of O atoms
B: 2 mol of SO_2 gives 2 mol of S atoms
C: 1 mol of CO_2 gives 1 mol of C atoms
D: 1 mol of N_2O gives 2 mol of N atoms

2 D

Cu: $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}4s^1$
Fe^{3+}: $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^5$
Ni^{2+}: $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^8$
Sr^{2+}: $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6$

3 C

A BrF_3: T-shaped (3bp, 2 lp)
B ICl_4^-: square planar (4bp, 2 lp)
C PCl_4^+: tetrahedral (4 bp, 0 lp)
D XeF_4: square planar (4bp, 2 lp)

4 A

(1 and 4 are correct)

1 True, bond angle in N_2H_4 is 107° while bond angle in H_2O_2 is 105°
2 False, the N–H bond is *longer* than the O–H bond as the O–H covalent bond in more polar. Students can also check the DB to compare the 2 bond energies.
3 False, hydrazine forms *weaker* intermolecular hydrogen bonds than hydrogen peroxide as N is less electronegative than O.
4 True, both N and O are sp^3 hybridised, and form σ bonds by overlapping with the s orbital of H.

5 D

Gases deviate from non-ideal behaviour at low temperature or high pressure hence option D is true.

Explanation for option D: At high pressure, volume of container decreases hence volume of gas particles is more significant compared to volume of container, therefore gas behave less ideally.

Note for option A, it should be the significant <u>intermolecular</u> hydrogen bonds between molecules that result in deviation from ideal gas behaviour (not the <u>intramolecular</u> covalent bonds between atoms).

6 C

amount of water formed

$$= \frac{25.0}{1000} \times 3.00 = 0.07500 \text{ mol}$$

heat produced

$$= (25.0 + 25.0) \times 4.18 \times 9.5 \times \frac{100}{85}$$

$$= 2335 \text{ J mol}^{-1}$$

$$\Delta H_n = -\frac{2335 \times 10^{-3}}{0.07500}$$

$$= -31.14$$

$$= -31.1 \text{ kJ mol}^{-1}$$

7 C

$\Delta H^\circ_{lattice\ energy}$ CaO
= – ($\Delta H^\circ_{atomisation}$ Ca + 1st and 2nd ionisation energies of calcium + $\Delta H^\circ_{atomisation}$ O + first and second electron affinity for oxygen) + $\Delta H^\circ_{formation}$ CaO

Option A: Less exothermic
Option B: Less exothermic
Option C: More exothermic since 1st and 2nd ionisation energies of magnesium are more endothermic than calcium
Option D: No change since standard enthalpy change of combustion of calcium is equal to the standard enthalpy change of formation of calcium oxide.

8 D

1/ time presents rate of reaction
Since first order wrt H_2O_2, hence
$[H_2O_2]$ α 1 / time

9 B

$$\frac{96-80}{96} = \left(\frac{1}{2}\right)^{t/35}$$

t = 90.5 min

10 C

$[Q]_{eqm}$ = 0.2 / 5 mol dm^{-3}
$[PQ_3]_{eqm}$ = 0.5 / 5 mol dm^{-3}
Initial P = 0.2 mol

Since P and PQ_3 have the same mole ratio in the equation,
|change in P| = |change in PQ_3| = 0.1
(read off from graph)

Alternatively, you can also find change in P = 1/3 change in Q.

Hence $[P]_{eqm}$ = (0.2 – 0.1) = 0.1 / 5 mol dm^{-3}

$$K_c = \frac{[PQ_3]}{[Q]^3[P]} = \frac{(\frac{0.5}{5})}{(\frac{0.2}{5})^3(\frac{0.1}{5})} = \frac{0.5 \times 5^3}{0.2^3 \times 0.1}$$

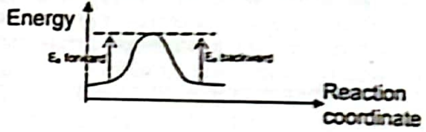
11 B

If equilibrium constant is independent of temperature, it means when temperature changes, neither forward nor backward reaction is favoured and this is only possible if ΔH is zero.

1. All rate constants are affected by temperature according to Arrhenius equation: $k = A^{-Ea/RT}$.

2. Temperature would have no effect on POE if ΔH is zero.

3. When ΔH is zero, activation energies for forward and backward reaction are equal as shown in the energy profile diagram below.



4. We cannot deduce any information about ΔS unless some information about how value of equilibrium constant changes with pressure is provided.

12 A

A pH of 0.010 mol dm^{-3} acetic acid = - lg ($\sqrt{10^{-4.76}(0.10)}$) = 2.88
B The solution contains a basic salt hence pH > 7.
C A buffer at maximum buffering capacity of formic acid and its salt is formed. pH = pKa = 3.74
D As more hydroxide is added compared to option C, pH of D > C but pH D < 7 as it is an acidic buffer.

13 C

1: $K_D = 10^{-14.8}$
$[D^+] = \sqrt{10^{-14.8}} = 3.98 \times 10^{-8}$
pD = 7.4

2: Since $[H^+]$=$[OH^-]$, D_2O is netural.

3: $K_D = 10^{-14.8} < K_w = 10^{-14}$ hence D_2O dissociates to a smaller extent than H_2O.

14 C

Chloride of W dissolves in water and turns blue litmus red: W is not Na (NaCl is neutral)

X is a good conductor of electricity but insoluble in water. X can be Mg or Al (However, since Y is Mg, X must be Al)

Oxide of Y has the highest melting point: MgO (Y is Mg)

Z has the highest first ionisation energy and largest ionic radius. (Z is P)

Since the four elements in Period 3 must be consecutive, W must be Si.

Hence the order is Y, X, W, Z.

(Mg, Al, Si, P)

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15 A

$MCO_3 \rightarrow MO + CO_2$

Down the group, solubility of oxides increases and pH of the solution increases.

$MgO + H_2O \quad Mg(OH)_2$

$BaO + H_2O \rightarrow Ba(OH)_2$

MgO dissolves sparingly in water to form weak base $Mg(OH)_2$ whereas BaO dissolves readily in water to form strong base, $Ba(OH)_2$.

Since pH of the saturated solution is less than that of limewater, $Ca(OH)_2$, M must be Mg.

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16 D

$Ag^+(aq) + Cl^-(aq) \quad AgCl(s)$ – white ppt

$Ag^+(aq) + I^-(aq) \quad AgI(s)$ – yellow ppt

$Ag^+(aq) + 2NH_3 \quad [Ag(NH_3)_2]^+$

Only AgCl dissolves in conc NH_3, AgI remains insoluble in conc NH_3. Hence Y is AgI(s) – yellow ppt.

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17 A

Enthalpy change of vaporisation is inversely proportional to boiling point.

Halogens have simple molecular structure with weak instantaneous dipole-induced dipole forces (id-id) between molecules.

As the number of electrons or size of electron cloud increases, the electron cloud gets more polarised, id-id forces increases down the group. More energy required to overcome id-id forces. Boiling point increases and hence ΔH_{vap} decreases down the group.

Thermal stability of HX decreases down group 17 due to decreasing bond strength of H–X (increasing H–X bond length)

Electrode reaction	E° / V
$F_2 + 2e^- \quad 2F^-$	+2.87
$Cl_2 + 2e^- \quad 2Cl^-$	+1.36
$Br_2 + 2e^- \quad 2Br^-$	+1.07
$I_2 + 2e^- \quad 2I^-$	+0.54

$E^\circ(X_2|X^-)$ becomes less positive down the group, oxidising power of elements decreases down the group.

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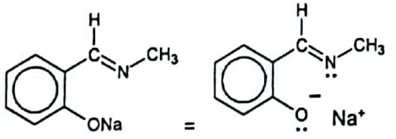
18 B

A The red complex ion absorbs complementary colour (green) at room temperature.

B



$$n(Ni^{2+}) = 3.0\times10^{-3}\times\frac{4}{1000} = 1.2\times10^{-3}\ \text{mol}$$

$$n(Q) = 4.0\times10^{-3}\times\frac{6}{1000} = 2.4\times10^{-3}\ \text{mol}$$

$$\frac{n(Ni^{2+})}{n(Q)} = \frac{1.2\times10^{-3}}{2.4\times10^{-3}} = \frac{1}{2}$$

Since Q is a bidentate ligand (lone pair on N and lone pair on O^- for dative bonding), the co-ordination number of nickel(II) complex is 4.

C The overall charge of the nickel(II) complex is 0 as there are 2 ligands of Q to one nickel(II) ion.

D The shape of the nickel(II) complex ion is not linear as the co-ordination number is not 2.

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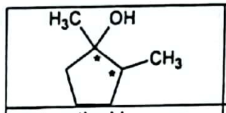
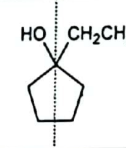
19 C

	
4 optical isomers	4 optical isomers
	
no cis-trans isomer no optical isomer as contains an internal line of symmetry	

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20 D (1,3 and 4)

Option 1 (incorrect)

The surface area decreases from primary (elongated) to secondary to tertiary alcohol (spherical). Hence strength of id-id forces of attraction decreases from primary to secondary to tertiary.

Option 2 (correct)

CH_3CH_2COCl hydrolyses in water to produce a strong acid, HCl. Hence the pH of its aqueous solution is the lowest. $CH_3CH_2CONH_2$ contains an amide functional group which is neutral. $CH_3CH(Cl)CH_2NH_2$ contains an amine functional group which is basic and hence its pH value is the highest.

Option 3 (incorrect)

The ease of hydrolysis of the chlorine atoms ~~decreases~~ increases from chlorobenzene to chloroethane to ethanoyl chloride.

Option 4 (incorrect)

Acidity decreases from ethanoic acid to phenol to ethanol.

Ethanoic acid is the strongest among the three, hence its conjugate base, ethanoate ion will be the weakest, with the largest pK_b value.

Ethanol is the weakest among the three, hence its conjugate base, ethoxide ion will be the strongest, with the smallest pK_b value.

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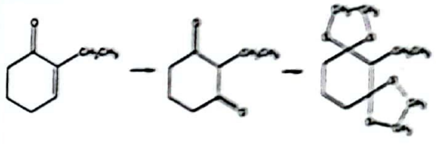
21 D



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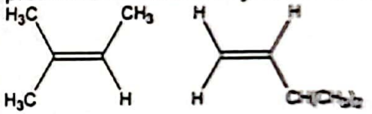
22 C

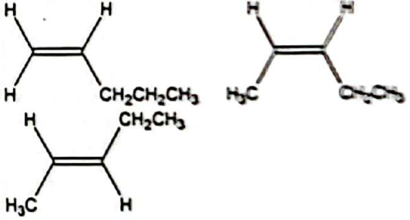
A and B do not contain methyl alcohol, hence will not be able to react with alkaline aqueous iodine.

C, $(CH_3)_2CHCH(OH)CH_3$ and D, $(CH_3CH_2CH_2CH(OH)CH_3)$ contain methyl alcohol, hence will react with alkaline aqueous iodine.

When C undergoes dehydration, it produces two alkenes only as shown below.



When D undergoes dehydration, it produces three alkenes as shown below.



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23 B

All can occur at a good rate at room temperature (20 °C) except

$CH_3CH_2OH + KBr \rightarrow CH_3CH_2Br + KOH$ as conc. H_2SO_4 needs to be added to react with KBr with heating to produce HBr which will then reacts with CH_3CH_2OH to produce CH_3CH_2OH.

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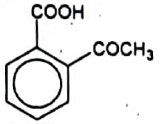
24 D

X contains an aromatic aldehyde that does not give a red ppt when warmed with Fehling's solution.

X reacts with acidified $K_2Cr_2O_7$ to give Y as shown below.



So Y also does not give a red ppt when warmed with Fehling's solution.

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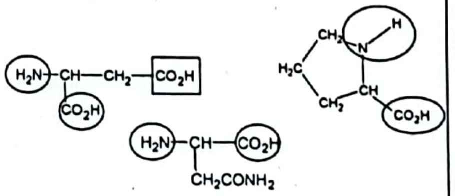
25 B

A dipeptide (formed in the body) should be formed between the carboxylic acid and amino group bonded directly to the α C i.e. see circles in black



Hence, only Option 1 and 4 is correct. Option 2 and 3 show structures that are bonded by the carboxylic acid group in the side chain of the 1st amino acid (look at the –COOH in the rectangle box) and are not classified as dipeptides formed in the body. Option 3 is incorrect.

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26 C (3 and 4)

Option 1:

The α–amino group should have a pK_a value of 9.0 because it is closer to the –COOH group which is withdrawing in nature.

Option 2:

Equal amounts of $H_3N^+CH(CO_2H)(CH_2)_4NH_3^+$ and $H_3N^+CH(CO_2^-)(CH_2)_4NH_3^+$ are present at point A.

Option 3:

At point C, $H_2NCH(CO_2^-)(CH_2)_4NH_3^+$ is present, which is a zwitterion with no net charge

Option 4:

At point B, $H_3N^+CH(CO_2^-)(CH_2)_4NH_3^+$ is present which has net positive charge, hence will migrate to cathode

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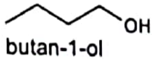
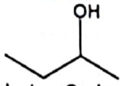
27 A

A butyl propanoate is formed by butan-1-ol and propanoic acid

The positional isomer of butan-1-ol is butan-2-ol as shown below.


butan-1-ol


butan-2-ol

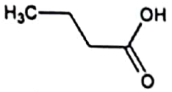
Propanoic acid has no chain isomerism.

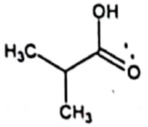
Both conditions fulfilled.

B ethyl butanoate is formed by ethanol and butanoic acid

Ethanol has no positional isomer.

Butanoic acid has 1 chain isomer as shown below.

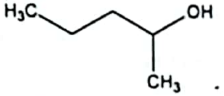

butanoic acid

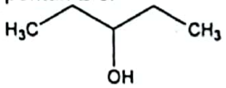

2-methylpropanoic acid

C pentyl ethanoate is formed by pentan-1-ol and ethanoic acid

Pentan-1-ol has 2 positional isomers as shown below.


pentan-1-ol


pentan-2-ol

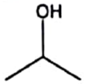

pentan-3-ol

Ethanoic acid has no chain isomerism.

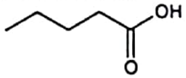
D Propyl pentanoate is formed by propan-1-ol and pentanoic acid

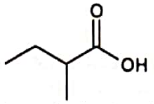
Propan-1-ol has 1 positional isomer.

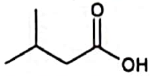

propan-1-ol

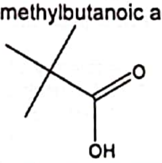

propan-2-ol

Pentanoic acid has 3 chain isomers as shown below.


pentanoic acid


2-methylbutanoic acid


3-methylbutanoic acid


2,2-dimethylpropanoic acid

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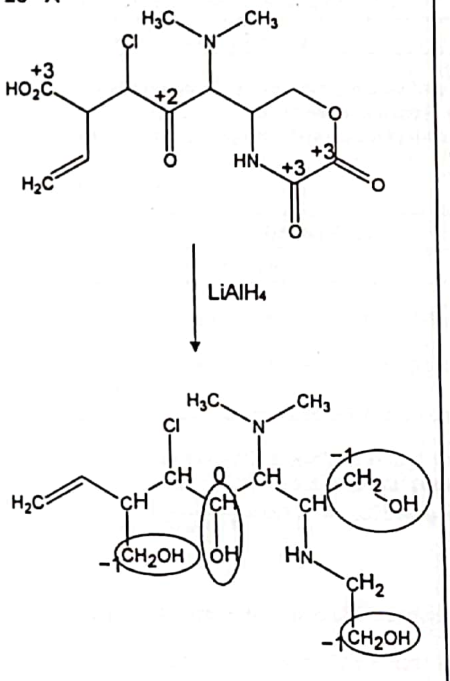
28 A



A (Correct) As a Lewis base, N_b has more electron-donating grps than N_a which increases the electron density on the N atom and hence the availability of the lone pair of electrons for donation to a Lewis acid. So N_b is a stronger Lewis base than N_a.

As a Bronsted-Lowry base, N_b experiences steric hindrance from the presence of 3 bulky alkyl grps, hence protons from the aq soln will have difficulty going near the lone pairs to form dative bond. So N_b is a weaker Bronsted-Lowry base than N_a.

B (Incorrect) When 96 dm^3 of H_2 gas was reacted with one mole of compound **W**, followed by excess sodium metal, at room conditions, the gas volume ~~expanded~~ contracted by 4824 dm^3.

96 dm^3 is equivalent to 4 mol of H_2 gas.

Only the alkene and ketone function grp will be reduced by $H_2(g)$ <u>using up 2 out of the 4 mol of $H_2(g)$ present</u>.

Alkene will be reduced to alkane while ketone will be reduced to 2° alcohol. The 2° alcohol and –COOH grp present will then react with Na to <u>produce 1 mol of $H_2(g)$</u>.

The final volume of $H_2(g)$ is 72 dm^3.

The gas volume contracted by 24 dm^3.

C Incorrect. The numbers written beside the C atom (as shown above) shows the oxidation state of the carbon before and after the reduction by $LiAlH_4$.

D Functional groups in **W** that will react with NaOH with heating are –COOH, RCl, amide and ester. So will need 4 mol of NaOH.

Functional groups in **W** that will react with NaOH without heating is –COOH. So will need 1 mol of NaOH.

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29 C

A: O.S. of C changes from +4 to +3 (reduction)

B: O.S. of Cr remains unchanged at +6

C: O.S. of Br changes from 0 to +3 (oxidation)

D: O.S. of Cl changes from 0 to –1 (reduction)

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30 A

$Fe^{3+} + e \rightarrow Fe^{2+}$ +0.77V → +ve → [R]
$Ni + 2e \rightarrow Ni^{2+}$ -0.25V → -ve → [O]

Fe^{3+} is yellow and Fe^{2+} is pale green.

Reduction occurs at the Fe^{3+}/Fe^{2+} half-cell.

E_{cell} = +0.77 – (-0.25) = +1.02 V.

Electrons flow from the anode (Ni^{2+}/Ni half-cell) to the cathode (Fe^{3+}/Fe^{2+} half-cell).

Pt cathode size remains unchanged.