Nanyang JC J2 Preliminary Examinations 2022
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	**A**	11	**C**	16	**D**	21	**B**	26	**C**
2	**C**	7	**D**	12	**D**	17	**A**	22	**D**	27	**D**
3	**B**	8	**D**	13	**A**	18	**C**	23	**A**	28	**B**
4	**D**	9	**B**	14	**B**	19	**C**	24	**A**	29	**A**
5	**B**	10	**C**	15	**B**	20	**D**	25	**A**	30	**D**

A: 7
B: 7
C: 7
D: 9

1 C

Step 1: $^{232}_{90}Th + ^{1}_{0}n \rightarrow ^{233}_{90}Th$
Law of conservation of mass, addition of one neutron increase nucleon number by 1, does not change the number of protons, element remains as Thorium.

Steps 2&3: $^{233}_{90}Th \rightarrow \rightarrow ^{233}_{92}U$
Decomposition of Q to uranium-233 does not involve addition of any new particles. Since two steps are involved, each should involve the decomposition of a neutron to a proton.

$$^{1}_{0}n \rightarrow ^{1}_{1}p + ^{0}_{-1}e^{-}$$

Therefore for each step, the proton number increase by 1, nucleon number remains the same.
Hence: $^{233}_{90}Th \rightarrow ^{233}_{91}Pa \rightarrow ^{233}_{92}U$
Neutron number of $^{233}_{91}Pa$ = 233 – 91 = 142

2 C

Comparing 3rd IEs,
Cd^{2+}: [Kr] $4d^{10}$
Rb^{2+}: [Ar] $3d^{10}$ $4s^2$ $4p^5$
Sr^{2+}: [Ar] $3d^{10}$ $4s^2$ $4p^6$ or [Kr]
Xe^{2+}: [Kr] $4d^{10}$ $5s^2$ $5p^4$
Across each period, IEs increase. The species with the noble gas configuration has the highest IE. Therefore 3rd IE of Rb < 3rd IE of Sr
Down the group, IEs decrease. Hence, for ions with noble gas configurations, we'd expect the trend:

[Kr] < [Xe]

where [Xe] is [Kr] $4d^{10}$ $5s^2$ $5p^6$, for 3rd IE, a 2+ ion with this configuration is Ba^{2+}.
Hence $Cd^{2+} < Ba^{2+}$ and $Xe^{2+} < Ba^{2+}$.
Since $Ba^{2+} < Sr^{2+}$, Sr^{2+} has the highest 3rd IE.

3 B

Solid Ga exist as covalent Ga_2 dimers, Ga−Ga molecules. There are weak instantaneous dipoles – induced dipoles attractions between the dimers which account for the low melting point. No strong covalent bonds need to be broken when Ga melts. Hence B is used to explain the low melting point of Ga but C is not.

Liquid Ga can be considered as having strong metallic bonding with high boiling point due to the number of delocalised valence electrons present. Hence A is used to explain the boiling point of Ga.

4 D

First, assume volume of the tyre is a constant at its maximum as long as internal pressure exceeds external pressure. i.e. the tyre will expand to its full volume and remains at its full volume when $p_{internal} > p_{external}$.

Simplifying pV=nRT gives $\frac{p_{sea\ level}}{T_{sea\ level}} = \frac{p_{luggage}}{T_{luggage}}$

$$p_{luggage} = p_{sea\ level} \times \frac{T_{luggage}}{T_{sea\ level}}$$

$$p_{luggage} = 6.8 \times \frac{(273 + 2)}{(273 + 30)}$$

$$p_{luggage} = 6.17 \text{ bar}$$

In the luggage hold,
difference in pressure = 6.17 – 0.47 = 5.7 bar
Hence, within the maximum allowed difference of 6 bar. Tyre will neither deflate nor burst.

A is wrong. When temperature decrease from 30°C to 2°, pressure will also decrease as pressure is proportional to temperature.

Bicycle tyres are generally engineered to work even at 0°C and below. (You can cycle in winter!)

5 B

Using $\frac{pV}{T}$ = nR, we can see the gradient of a plot of pV against T gives nR.
For gas D, nR = 498.6/600 = 0.831. Amount of gas D is 0.831/8.31 = 0.1 mol.
Since gradient for gas E is roughly double, amount of gas E is 0.2 mol.
From calculations of amount,
34.02 g of $SiCl_4$ and 12.82 g of SO_2 both gives 0.2 mol. 3.100 g of P and 0.2000 g of H_2 both gives 0.1 mol. Hence C and D are wrong.
E is a gas at 300 K. Hence 0.2 mol of SO_2 (gas at rtp) is more likely to be gas E than 0.2 mol of $SiCl_4$ (liquid at rtp).
NB: 0.2 mol of SO_2 has a pV < 498.6 due to negative deviation from ideal gas behaviour. Presence of significant instantaneous dipole – induced dipole attractions cause real gases to exert a smaller pressure than expected.

6 A

A is correct. 1 mol of $CO_2(g)$ is formed from 1 mol of C(graphite) which is a solid at standard conditions and 1 mol of O_2 gas.

B is wrong. ΔH_{neut} is for 1 mol of water formed between the reaction of an acid and an alkali.

C is wrong. The equation given is for ΔH_{hyd}, enthalpy of hydration.

D is wrong. The equation given is for 1st EA + 2nd EA of sulfur.

7 D

		ΔG⦵	ΔS⦵
1	$SO_3(l) + H_2O(l) \rightarrow H_2SO_4(aq)$	–	+
2	$Cl_2(g) + 2I^-(aq) \rightarrow I_2(aq) + 2Cl^-(aq)$	–	–
3	$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$	+	+

8 D

A cannot prove order wrt CN^-. As rxn proceeds, $[CN^-]$ remains relatively constant as it is in huge excess. To deduce order wrt to CN^-. we look at how rate changes as $[CN^-]$ changes. Since $[CN^-]$ does not change, any change in rate is not due to CN^-.

B is the opposite of A. It would allow us to determine order wrt CN^-. However, the graph of [(1-bromoethyl)benzene] is plotted instead. We cannot determine order wrt CN^- when the rate appears to be zero.

C is wrong. When the same concentrations of $[CN^-]$ and [(1-bromoethyl)benzene] are used, the decrease in concentrations must follow the same shape i.e. since we know the graph of [(1-bromoethyl)benzene] against time follows 1st order kinetics with constant half-lives, the graph of $[CN^-]$ against time must follow the same overall first order kinetics with constant half-lives.

D is therefore the correct answer. Another way to understand why the shape of the graph of $[CN^-]$ against time will show constant half-lives is to recognise the mechanism as S_N1. In the slow step, [(1-bromoethyl)benzene] decreases following first order kinetics. Any carbocation formed immediately reacts with CN^- in the fast step. Hence the decrease in $[CN^-]$ will mirror the decrease in [(1-bromoethyl)benzene].

9 B

The operating conditions of Haber process is 500 °C and 60 atm in the presence of Fe catalyst. A mid-high temperature is used to increase rate of reaction. Very high temperatures shift POE to the left, favouring backward endothermic reaction to absorb heat energy and resulting in poor yield. Low temperatures cause the equilibrium to be established too slowly. A relatively high pressure of 60 atm is used to shift POE to the right to reduce total amount of gas particles. 500 atm is too high resulting in the need for very thick steel containers and high costs.

10 C

pKw = pH + pOH

A: pH = 1. $[H_3O^+]$ = 0.1 mol dm^{-3}.
$[HCl]$ = 0.1 mol dm^{-3}

B: pH = 1. $[H_3O^+]$ = 0.1 mol dm^{-3}.
$[HCl]$ = 0.1 mol dm^{-3}

C: pH = 13. pOH = 13.5 – 13 = 0.5
$[NaOH] = 10^{-0.5} = 0.316$

D: pH = 13. pOH = 14.5 – 13 = 1.5
$[NaOH] = 10^{-1.5} = 0.0316$

Hence, C has the highest concentration of ions.

11 C

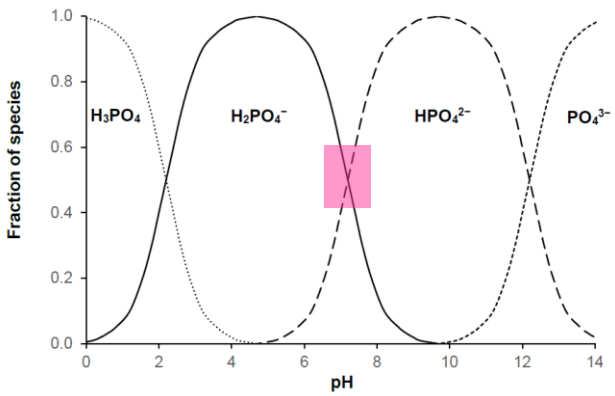
First, calculate the pKa values.

	Ka	pKa
A	6.3×10^{-3}	2.2
B	2.0×10^{-5}	4.7
C	6.3×10^{-8}	7.2
D	2.0×10^{-10}	9.7

To determine K_{a2}, use the H−H equation.

$$pH = pK_{a2} + \lg \frac{[HPO_4^{2-}]}{[H_2PO_4^-]}$$

At maximum buffer capacity, $[HPO_4^{2-}] = [H_2PO_4^-]$, $pH = pK_{a2}$. Hence, we need to find the point in the graph where $[HPO_4^{2-}] = [H_2PO_4^-]$.



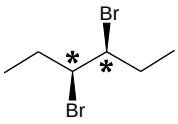
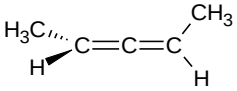
From graph, when $[HPO_4^{2-}] = [H_2PO_4^-]$, pH ~ 7.2.

12 D

$CH_3COCO_2H + OH^- \rightarrow CH_3COCO_2^- + H_2O$

At equivalence point, a weakly alkaline solution where pH > 7 is formed. Hence answer is D.

13 A

		Chiral Carbons	Plane of Symmetry
1		Yes	No
2		Yes	No
3		No	No

All three molecules rotate plane-polarised light as all does not have a plane of symmetry.

14 B

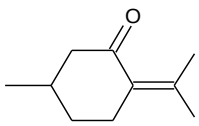
A is correct. This can be seen from step 2. The monomers, $CH_2=CH_2$, are added together to form the polymer, $(CH_3)_3C-O-(CH_2CH_2)_nCH_2CH_2•$, using free radicals $(CH_3)_3C-O•$.

B is wrong. The formation of free radical in step 1 involves homolytic fission where the two electrons of the O−O bond goes back to each O atom, $(CH_3)_3C-O•$.

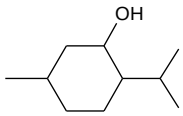
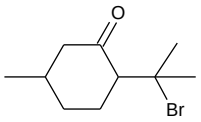
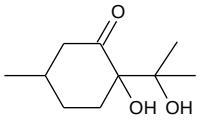
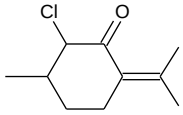
C is correct. In a propagation step, a free radical, $(CH_3)_3C-O•$ reacts with a molecule, $CH_2=CH_2$ to form a free radical intermediate, $(CH_3)_3C-O-CH_2CH_2•$, which can further propagate the reaction.

D is correct. Two free radicals combine together, destroying both radicals so that both can no longer propagate the reaction.

15 B



pulegone

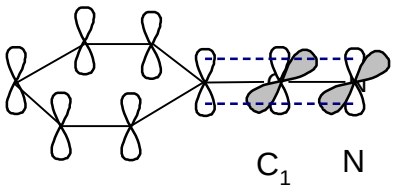
		Type of reaction
A		reduction
B		electrophilic addition
C		oxidation
D		free radical substitution

16 D

1 is wrong. The benzene carbons have a bond order of 1.5.

2 is wrong. The central carbon is sp^3 hybridised. It is not planar.

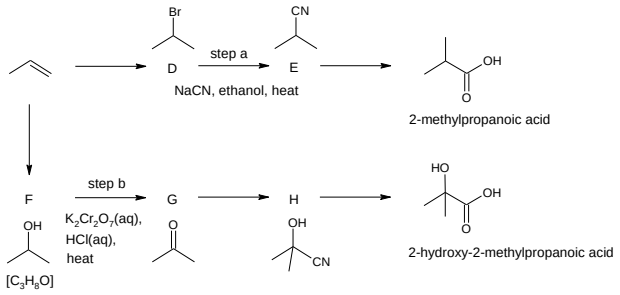
3 is correct.



benzene

Both C_1 and N are sp hybridised. Lobes in white overlaps. Lobes in black does not.

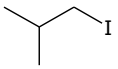
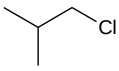
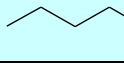
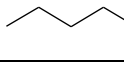
17 A



18 C

Factor	Explanation	Favours
Steric	Bulky groups block the approach of nucleophiles	Primary RX
Solvent Effect	Protic solvents with –OH groups stabilise ionic reactants; hence increasing activation energy	Solvents without –OH groups
Bond length	Less energy required to break C-I bonds than C-Cl bonds	R-I reacts faster than R-Cl

Therefore the reactivity

	Reactant	Steric	Solvent	Bond
A		1° ✓	-OH	C-I ✓
B		1° ✓	no –OH ✓	C-Cl
C		1° ✓	no –OH ✓	C-I ✓
D		1° ✓	-OH	C-Cl

19 C

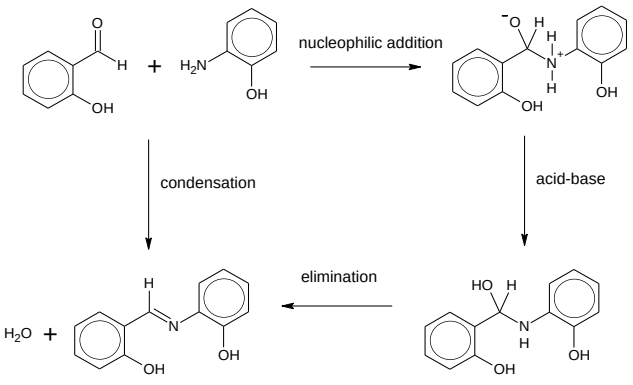
A has 0 degree of unsaturation. Cannot be alkene.

B has 1 degree of unsat which is a carbonyl compound. Cannot have alkene.

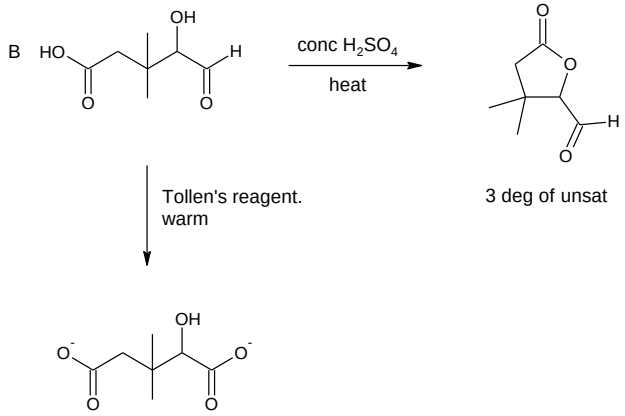
C has 2 degree of unsat. One is a carbonyl, hence the other must be the alkene.

D has 4 degree of unsat, therefore benzene ring is present as a phenol. Cannot have alkene.

20 D



21 B



A does not undergo condensation to form a cyclic ester. Such an ester would have to form a 3-membered ring with huge ring strain. (A nucleophilic addition product where the OH adds to the carbonyl will give a product with a different degree of unsat, i.e. different molecular formula)

C does not have carboxylic acid group for condensation to form an ester. Elimination of H_2O to form an alkene results a compound with the wrong formula. (A nucleophilic addition product will give a product with a wrong formula.)

D can undergo condensation to form a cyclic ester, however the degree of unsaturation of the product will be wrong, different molecular formula.

22 D

For gas phase basicity, only consider the effect of electron-donating and electron-withdrawing groups. Steric effect does not apply in gas phase basicity.

1 is correct. Phenyl groups are electron-donating by electronic effect.

2 is not used. Steric factors does not apply for gas phase basicity.

3 is wrong. There are no negative charge on the amines.

23 A

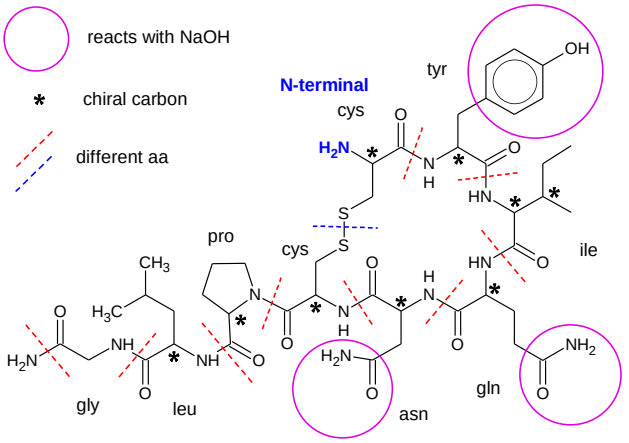
A is correct. The electron-withdrawing acyl group bonded to a quarternary amide salt will destablise the salt, preventing its formation. This is unlike in alkylation where the four electron-donating groups bonded to the quarternary amine salt stabilise the cation formed.

B is wrong. Acyl groups are stronger electrophiles compared with chloroalkanes as the carbon in acyl chloride is bonded to two electronegative atoms making it strongly electron deficient.

C is wrong. The tertiary amine is a stronger nucleophile. But this does not explain why a stronger nucleophile does not react with the more electrophilic acyl chloride.

D is wrong. The absence of N-H bond does not prevent the tertiary amine from reacting with the chloroalkane. Hence the fact that the tertiary amine does not react with the stronger electrophile cannot be explained by the absence of N-H bonds.

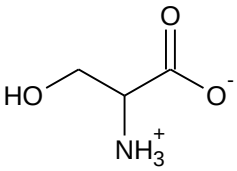
24 A

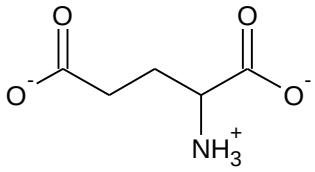
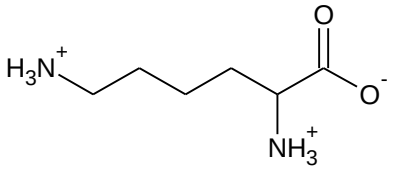
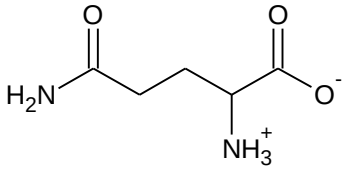


The N-terminal is cys.

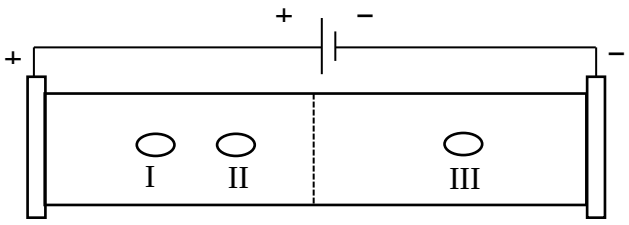
25 A

At pH 6, the dominant forms of the amino acids are shown.

A	

B	
C	
D	

The charges of the electrodes are shown.



Deduction
Spot III must be C as C is the only cation, hence attracted to the negative electrode.
Spot I must be B as B has the same magnitude of charge but opposite sign, and similar M_r as C.

To determine which is spot II, we need to compare A and D against B. Both A and D have slightly higher concentration of the anionic form than the zwitterion form at pH 6. Both are expected to move towards the positive electrode.

Comparing charge/M_r, A has lower charge but also lower M_r than B, hence A should move a similar distance as B. D has the same M_r as B, but lower charge, hence D should move significantly less than B. Therefore, spot II should be D.

26 C

$E\ominus(Al^{3+}/Al) = -1.66V$
For spontaneous reaction,
$E\ominus red > E\ominus(Al^{3+}/Al)$

Therefore, Al metal will reduce uranium(VI) ions, UO_2^{2+} to U^{3+} ions.

$$Al + UO_2^{2+} + 4H^+ \rightarrow Al^{3+} + U^{3+} + 2H_2O$$

27 D

Standard conditions for half-cells are:

Overall temperature = 298 K

$E\ominus(H^+/H_2)$	$E\ominus(MnO_2/Mn^{2+})$
$2H^+ + 2e^- \Leftrightarrow H_2$	$MnO_2 + 4H^+ + 2e^- \Leftrightarrow Mn^{2+} + 2H_2O$
1 mol dm^{-3} $H^+(aq)$	1 mol dm^{-3} $Mn^{2+}(aq)$
$H_2(g)$ at 100 kPa	1 mol dm^{-3} $H^+(aq)$

28 B

Using $Q=It$ and $Q=n_eF$, and the equations,
$Cu^{2+} + 2e^- \rightarrow Cu$
$Ni^{2+} + 2e^- \rightarrow Ni$

First, calculate the amount of electrons passing through the anode.

$n_e = (2.4 \times 4.2 \times 60 \times 60) / 96500$
$= 0.376$ mol

Next, calculate the total amount of Cu^{2+} and Ni^{2+} formed.

total n_{Cu2+} and $n_{Ni2+} = ½ \times n_e = 0.188$ mol

n_{Ni2+} formed $= 1.047 - 1.000 = 0.047$ mol

Hence, n_{Cu2+} formed $= 0.188 - 0.047$
$= 0.141$ mol

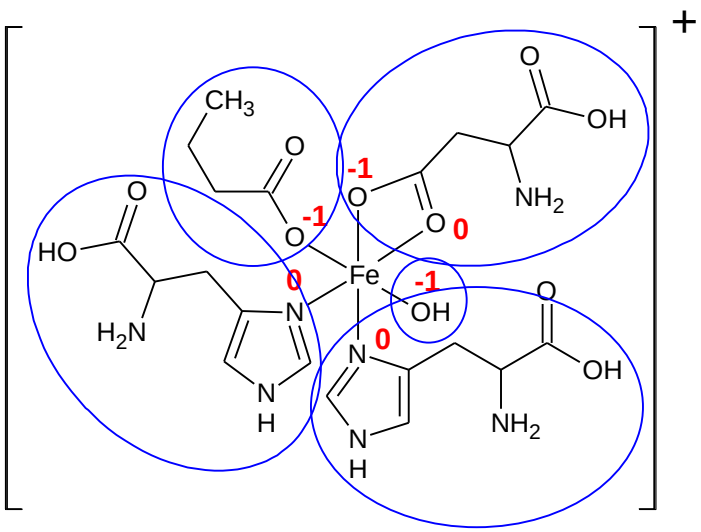
Decrease in anode mass
$= (0.047 \times 58.7) + (0.141 \times 63.5)$
$= 11.7$ g

29 A

From *Data Booklet*, this is the plot of atomic radius from Ca to Zn.

30 D

The charge of each atom dative bonded to Fe and the number of ligands is shown.



Since overall charge is +1, Fe has a charge of +4.
Fe is [Ar] $3d^6\ 4s^2$, hence,
Fe^{4+} has electronic configuration [Ar] $3d^4$
Hence both students J and K are correct.