Nanyang JC J2 Preliminary Examination 2020
H2 Chemistry 9729/01
Paper 1 MCQ Answers and Comments

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

1 B

There is 15 *g of N per* 100*g of fertiliser*.

n(N) in 100g fertiliser $= \frac{15}{14.0}$

$\therefore$ n(N) in 14g fertiliser $= \left(\frac{15}{14.0} \div 100\right) \times 14 = 0.150$ mol

0.150 mol is dissolved in 5 dm^3.

Hence conc of N atoms = $\frac{0.150}{5} = 0.030$ mol dm^{-3}

2 C

For protons, $\frac{charge}{mass} = 1$

angle of deflection = $k\frac{charge}{mass}$

+15 = k(1)
k = 15
For particle Y which is deflected by an angle of +5°,

$\frac{charge}{mass} = +\frac{5}{15} = +\frac{1}{3}$

	p	n	e	charge	mass	$\frac{charge}{mass}$
A	1	2	1	0	3	no deflection
B	3	3	5	−2	6	$-\frac{1}{3}$
C	4	5	1	+3	9	$+\frac{1}{3}$
D	4	5	3	+1	9	$+\frac{1}{9}$

Hence ans is **C**.

3 D

$BeCl_2$ and CO_2 (2 bp and 0 lp → linear)
BH_4^- and NH_4^+ (4 bp and 0 lp → tetrahedral)
OF_2 and SCl_2 (2 bp and 2 lp → bent)
PH_3 (3 bp and 1 lp → trigonal pyramidal);
SO_3 (3 bp and 0 lp → trigonal planar)

4 B

Energy released in forming the stronger intermolecular forces in liquid **Z** is greater than the energy absorbed in overcoming the intermolecular forces in liquid **X** and liquid **Y**. (option 1 is correct)

Since the boiling point of **Z** is higher, the vapour pressure of liquid **Z** will be less than that of either liquid **X** or liquid **Y.** (option 2 is correct)

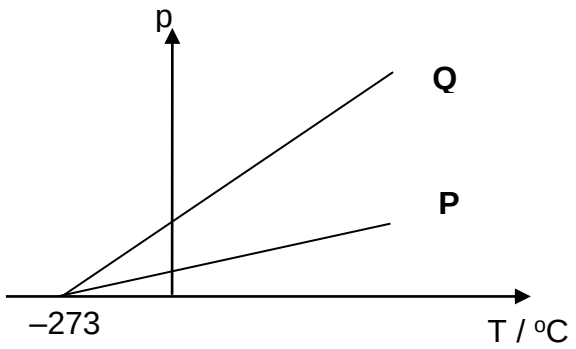
More energy is required to overcome the stronger intermolecular forces in liquid **Z**. Hence, the boiling point of liquid **Z** is higher than that of either liquid **X** or liquid **Y.** (option 3 is incorrect)

5 B

$pV = nRT \Rightarrow pV = \frac{mRT}{M} \Rightarrow p = (\frac{mR}{VM})T$

For graph of p against T, gradient = $\frac{mR}{VM}$

Since **P** has a larger M_r than **Q**, the graph for **P** has a less steep gradient.



For a fixed mass of gas at constant T,

$pV = \frac{mRT}{M}$ = constant

Hence, the graph of pV against p is a horizontal straight line (option D is incorrect).

Since **P** has a larger M_r than **Q**, the pV value for **P** is smaller than that for **Q** (option C is incorrect).

6 C

Energy absorbed by water

$= 250 \times 4.18 \times (100 - 12) \times 10^{-3}$

$= 91.96$ kJ

Energy evolved by combustion of butane

$= 91.96 \times \frac{100}{47}$

$= 195.6$ kJ

$195.6 = 2877 \times \frac{m(butane)}{58}$

$m(butane) = 3.944 \approx 3.94$ g

7 D

$$2SO_2(g) + O_2(g) \xrightarrow{\Delta H_r} 2SO_3(g)$$

$$2(-296.5) \quad -791.4$$

$$2S(s) + 3O_2(g)$$

$2(-296.5) + \Delta H_r = -791.4$

$\Delta H_r = -198.4$ kJ mol^{-1}

8 C

When [1-bromobutane] doubles $(\frac{0.2}{0.1} = 2)$, initial rate also doubles $(\frac{3.0 \times 10^{-5}}{1.5 \times 10^{-5}} = 2)$. Therefore, order of reaction with respect to 1-bromobutane is 1.

When $[HS^-]$ increased by 1.5 times $(\frac{0.3}{0.2} = 1.5)$, initial rate also increased by 1.5 times $(\frac{4.5 \times 10^{-5}}{3.0 \times 10^{-5}} = 1.5)$. Order of reaction with respect to HS^- is 1.

Hence, rate = k[1-bromobutane][HS^-], where both 1-bromobutane and HS^- are involved in the rate determining step.

Using Expt 1,

$1.5 \times 10^{-5} = k\ (0.1)(0.1)$

$k = 1.5 \times 10^{-3}$ mol^{-1} dm^3 s^{-1}

9 D

When the temperature increased, the Maxwell Boltzmann graph flattens out with the peak lower than T_1.

With the addition of catalyst, $E_{a(cat)}$ is lower as more particles with energy $\geq E_a$.

10 B

Pressure/ atm	$2NO_2$	$\rightleftharpoons$	$2NO$	+	O_2
Initial	a		0		0
Change	–y		+y		+0.5y
Eqm	a – y		y		0.5y

$p = a - y + y + 0.5y = 1.3a$

$\Rightarrow y = 0.6a$

mole fraction of oxygen $= \frac{p_{O_2}}{p_T} = \frac{0.5y}{p} = \frac{0.5(0.6a)}{1.3a} = 0.23$

11 C

Option	Change made
1	Increase in temperature • Increases both forward and backward rate • Favors endothermic reaction, so backward reaction is favoured, percentage yield decreases
2	Add a catalyst • Increases both forward and backward rate • No effect on POE, hence percentage yield remains unchanged
3	Increase in pressure • Increases both forward

	and backward rate • Favors reaction that produces lesser moles of gas, hence forward reaction favoured, yield increases

12 A

Brønsted-Lowry base is a proton acceptor
A NH_3 is a proton acceptor where it accepts H^+ from water.
B NH_3 is a nucleophile where it attacks the electron deficient C attached to Br.
C NH_3 is a reducing agent. Oxidation no. of nitrogen decreases from +3 in HNO_2 to 0 in N_2.
D NH_3 is proton donor as it donates H^+ to H^- which forms H_2.

13 A

$[H^+] = 10^{-pH} = 10^{-6} = 1.0 \times 10^{-6}$ mol dm^{-3}
Since $[H^+]$ is not the same [**X**] (= 2 mol dm^{-3}), **X** undergoes partial dissociation. It is a weak acid.

$$\text{Degree of dissociation} = \frac{1.0 \times 10^{-6}}{2}$$
$$= 5.0 \times 10^{-7}$$

$[OH^-] = 10^{-pOH} = 10^{-(14-9)}$
$= 1.0 \times 10^{-5}$ mol dm^{-3}
Since $[OH^-]$ is not the same [**Y**] (= 2 mol dm^{-3}), **Y** undergoes partial dissociation. It is a weak base.

$$\text{Degree of dissociation} = \frac{1.0 \times 10^{-5}}{2}$$
$$= 5.0 \times 10^{-6}$$

Extent of dissociation of **X** is less than **Y**.

Hence, student **R** and **S** gave the correct statements.

14 D

$Zn^{2+} + 2e \rightarrow Zn$ $\quad E^\ominus = -0.76$ V
$VO_2^+ + 2H^+ + e \rightarrow H_2O + VO^{2+}$ $\quad E^\ominus = +1.00$ V
yellow blue
$VO^{2+} + 2H^+ + e \rightarrow H_2O + V^{3+}$ $\quad E^\ominus = +0.34$ V
blue green
$V^{3+} + e \rightarrow V^{2+}$ $\quad E^\ominus = -0.26$ V

green purple

$E^\ominus_{cell} = (+0.34) - (-0.76) = +1.10$ V

$E^\ominus_{cell} = (-0.26) - (-0.76) = +0.50$ V

Colour change will be from blue to green to purple (final colour).

15 A

$2HOCl + 2H^+ + 2e \rightarrow Cl_2 + 2H_2O$ $\quad +1.64$ V
$I_2 + 2e \rightarrow 2I^-$ $\quad +0.54$ V
1 $E^\ominus_{cell} = E^\ominus (HOCl/Cl_2) - E^\ominus (I_2/I^-)$
$= +1.64 - (+0.54) = +1.10$ V
2 The size of the electrode has no impact on $E^\ominus_{cell}$
3 $\Delta G = -nFE^\ominus_{cell} = -2(96500)(1.10)$
$= -212300$ J mol^{-1} $= -212.3$ kJ mol^{-1}
4 AgI is precipitated, lowering $[I^-]$.
POE for $I_2 + 2e \rightarrow 2I^-$ shifts right to increase $[I^-]$, $E^\ominus (I_2/I^-)$ becomes more positive.
Since $E^\ominus_{cell} = E^\ominus (HOCl/Cl_2) - E^\ominus (I_2/I^-)$, $E^\ominus_{cell}$ becomes less positive

16 D

In general, across a period,
- atomic size decreases due to increasing nuclear charge and constant shielding effect. **(So A is WRONG)**
- Ionic radii decreases from Na^+, Mg^{2+}, Al^{3+}, Si^{4+} and N^{3-}, O^{2-}, F^- due to increasing nuclear charge and constant shielding effect. **(So B & C are WRONG)**
- Anions are larger than cations because anions contain one more electron shell. F^- should be larger than Ne or Na^+. D is the answer.

(Note this is an exact CIE qn and D is the best option)

17 D

$Mg(NO_3)_2 \xrightarrow{\text{sodium carbonate solution}} MgCO_3$ **white ppt** $\xrightarrow{\text{excess HCl(aq) then boil}} MgCl_2$ **colourless soln** $\xrightarrow{\text{excess NaOH(aq)}} Mg(OH)_2$ **white ppt**

$Ba(NO_3)_2 \xrightarrow{\text{excess ammonia}}$ no ppt $\xrightarrow{\text{excess } H_2SO_4(aq)} BaSO_4$ **white ppt** $\xrightarrow{\text{excess NaOH(aq)}} BaSO_4$ remains **white ppt**

Students should refer to the Data Booklet for reactions of Mg and Ba ions with alkali

18 D

Property **Q** of chlorine is **larger** than that of iodine for 1,2 & 4.

1 oxidising ability of the element (True, oxidising power of halogens decrease down the group)

2 solubility of the silver halide in $NH_3(aq)$ (True, AgCl is soluble in $NH_3(aq)$ while AgI is only soluble in conc NH_3)

3 strength of intermolecular forces between molecules of the element (False, iodine has a bigger e cloud to be polarized, hence id-id forces of attraction are stronger between iodine molecules)

4 thermal decomposition temp of the hydrogen halide

(True, H-X bond increases in length down the group, hence HCl is more thermally stable, and thermal decomposition temp decreases down the group)

19 D

A "Bromine does not dissolve in water."

(Bromine can dissolve in water so the report is correct)

B "Bromine does not vapourise readily." (Bromine has simple molecular structure and hence relatively low bpt. Hence the report is correct)

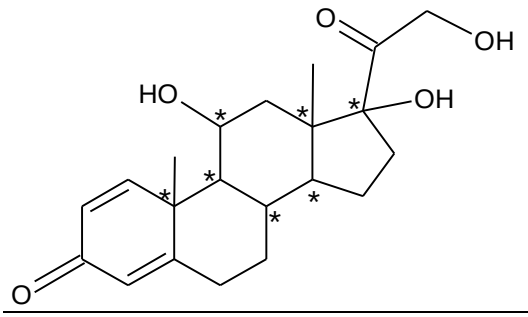
C "Bromine is less dense than air."

(Bromine is denser than air as the Mr of Br_2 is higher than N_2 - the major component of air. Hence the report is correct)

D "Gaseous bromine is not orange."

(Gaseous bromine is reddish brown - refer to DB. Hence the report is wrong)

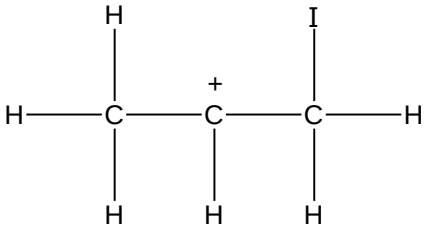
20 B



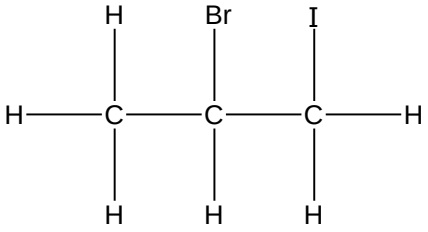
21 C

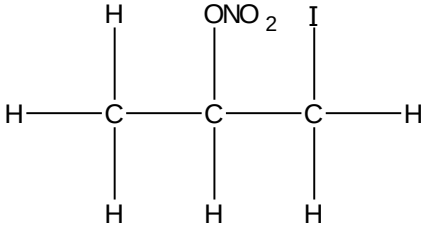
Propene undergoes electrophilic addition with iodine monobromide.

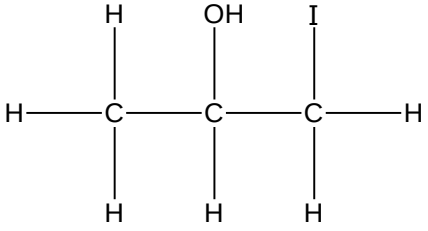
Step 1 involves the formation of the more stable 2° carbocation intermediate:



Step 2 involves the attack of the three possible competing nucleophiles: Br^-, NO_3^- and H_2O to give a mixture of products.



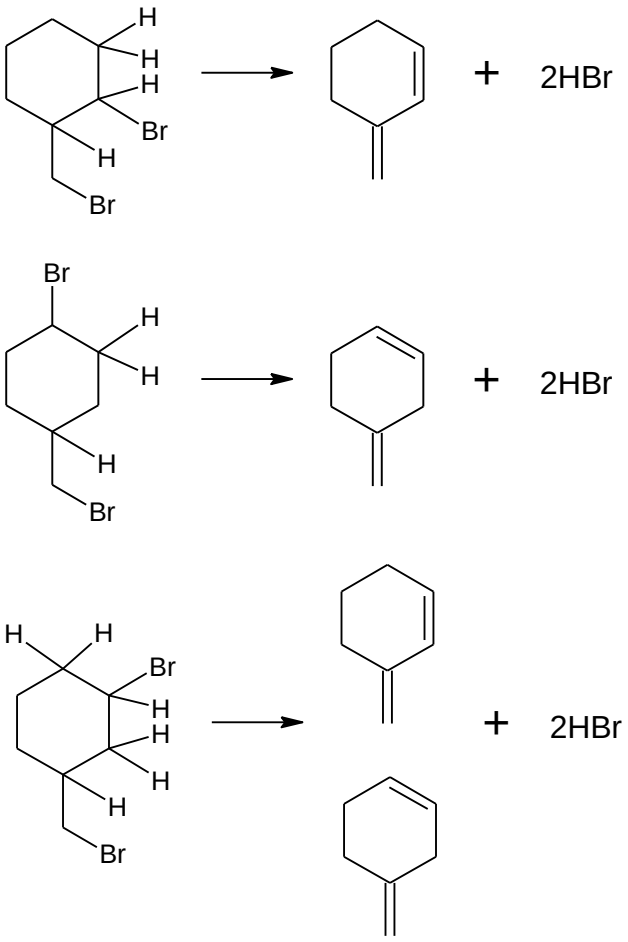




22 A

ethene (28.0) → ethane-1,2-diol (62.0) increase by 34.0
ethylbenzene (106.0) → benzoic acid (122.0) increase by 16.0
chloroethane (64.5) → ethylamine (45.0) decrease by 19.5
chloroethane (64.5) → propanenitrile → propylamine (59.0) decrease by 5.5

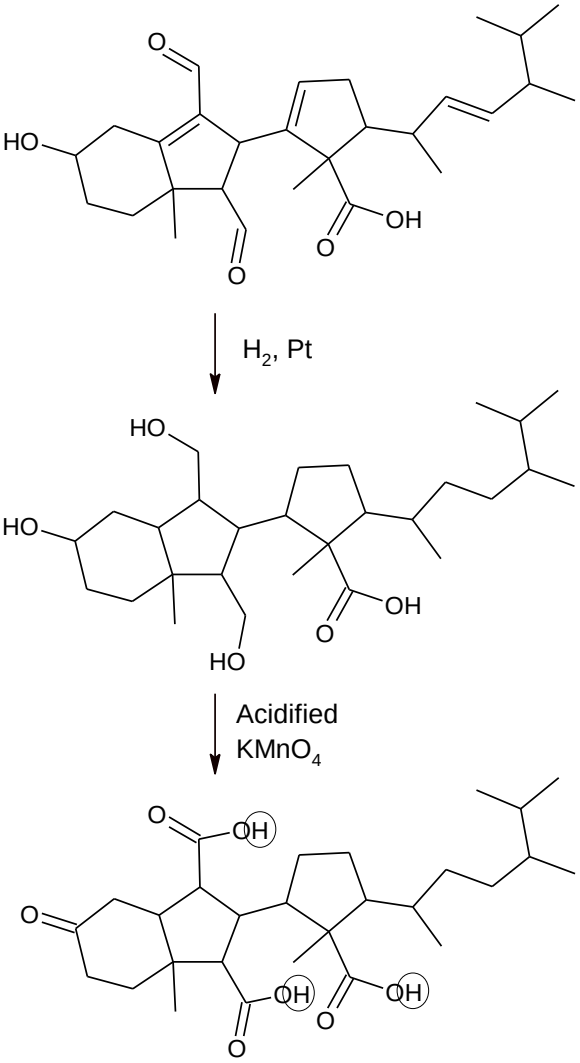
23 B



24 A

Functional group	aq. $AgNO_3$ w/o heat	aq. NaOH with heat
CH_3COCl C_6H_5COCl	✓	✓
$CH_3(CH_2)_3Cl$	x	✓
C_6H_5Cl	x	x

25 B



product S

The circled hydrogens can be displaced with sodium metal (ie. can react with Na).

26 B

$H_2NCH_2CH_2COO^-$ Na^+ will be the most basic due to the presence of the basic $–NH_2$.

Least basic salt ⇒ Most acidic conjugate acid

In order of most acidic to least acidic:
$CH_3CH_2CHClCOOH$ >
$ClCH_2CH_2CH_2COOH$ > $CH_3CH_2CH_2COOH$

In order of least basic to most basic:
$CH_3CH_2CHClCOO^-$ Na^+ <
$ClCH_2CH_2CH_2COO^-$ Na^+ <
$CH_3CH_2CH_2COO^-$ Na^+

27 A

$CH_3CH_2CO_2CH_2CH_3 + NaOH$
$\rightarrow CH_3CH_2OH + CH_3CH_2CO_2^- Na^+$

M_r of $CH_3CH_2OH = 46.0$
M_r of $CH_3CH_2CO_2^- Na^+ = 96.0$

Percentage by mass of CH_3CH_2OH
$= \frac{46.0}{46.0 + 96.0} \times 100 = 32.4\ \%$
Percentage by mass of $CH_3CH_2CO_2^- Na^+$
$= 100 - 32.4 = 67.6\ \%$

28 B

FG	Br_2 (aq)	HBr (g)	acidified $K_2Cr_2O_7$ (aq)	2,4-DNPH
2 x 2° alcohol	x	NS with 2 mol of HBr (g)	oxidised by $K_2Cr_2O_7$ (aq) but no CO_2	x
1 x 3° alcohol	x	NS with 1 mol of HBr (g)	x	x
1 x carbo-xylic acid	x	x	x	x
1 x ester	x	x	hydrolysed by acid (dil H_2SO_4) but no CO_2	x
1 x alkene	EA with 1 mol of Br_2(aq)	EA with 1 mol of HBr (g)	x	x
2 x phenol	ES with 3 mol of Br_2(aq) $\Rightarrow$ 2,4,6-sub with respect to each phenol	x	x	x

29 D

$$CH_3CH{=}CHCH_3 \xrightarrow[D_2O]{Br_2} CH_3CH_2BrCH_2(OD)CH_3$$

$$CH_3CH_2CH(OH)CH_2I \xrightarrow[D_2O]{I_2,\ NaOD,} CH_3CH_2COO^- Na^+ + CDI_3$$

$$CH_3CH_2CONHCH_3 \xrightarrow[\text{dry ether}]{LiAlD_4} CH_3CH_2CD_2NHCH_3$$

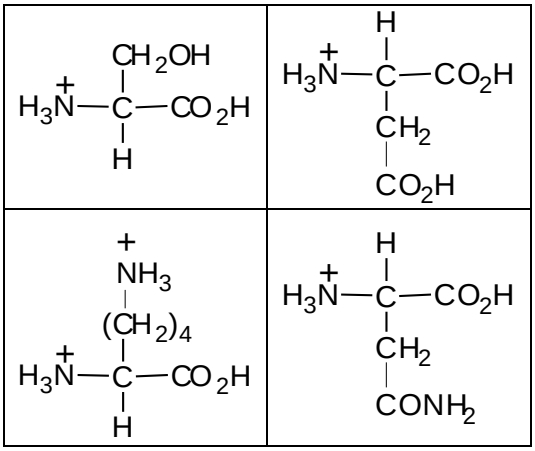
$$(CH_3)_3COD \xrightarrow[\text{heat}]{\text{conc } D_2SO_4} H_3C{-}C(CH_3){=}CH_2$$

30 D

These are all α-amino acids with the general formula $RCH(NH_2)CO_2H$ (option 1 is correct).

The amino acids exist as zwitterions in water which are soluble in water due to the formation of ion–dipole interactions between zwitterions and water molecules (option 2 is incorrect).

When buffered at pH 2, all four species will migrate to the cathode (negative terminal) during electrophoresis since they are positively charged (option 3 is incorrect).



Note: Alcohols and amides are not affected by pH since alcohols do not react with base and amides do not react with acid.