Anderson Serangoon Junior College
2020 JC2 Preliminary Examination
H2 Chemistry (9729) Paper 1 Worked Solutions.

1 Beams of charged particles are deflected by an electric field.

In an experiment, protons are deflected by an angle of +15º. In another experiment, under identical conditions, particle **A** is deflected by an angle of –5º.

What could be the composition of particle **A**?

	protons	neutrons	electrons
A	1	2	2
B	3	3	2
C	3	3	4
D	4	5	1

Answer: A

Particle **A** is deflected to the opposite direction as proton
⇒ it is negatively charged (i.e. electrons are more than protons)
⇒ options **A** and **C** are possible answer.
Next, note that both are singly charged
⇒ the mass of particle **A** must be 3 times that of proton (i.e. sum of proton and neutron is 3)

Alternatively, work out the details as follow.

Angle of deflection, $\theta \propto \frac{z}{m}$

For a proton, ${}^{1}_{1}H^{+}$, $\frac{z}{m} = \frac{+1}{1} = +1$

For particle **A**, $\frac{z}{m} = \frac{-5°}{+15°}(+1) = -\frac{1}{3}$

A : ${}^{3}_{1}A^{-}$ **B** : ${}^{6}_{3}A^{+}$ **C** : ${}^{6}_{3}A^{-}$ **D** : ${}^{9}_{4}A^{3+}$

	protons	neutrons	electrons	Charge overall	m	e/m
A	1	2	2	–1	3	–1/3
B	3	3	2	+1	6	+1/6
C	3	3	4	–1	6	–1/6
D	4	5	1	+3	9	+1/3

2 50 cm^3 of a 0.10 mol dm^{-3} solution of a metallic salt was found to react exactly with 25.0 cm^3 of 0.10 mol dm^{-3} aqueous sodium sulfite.

In this reaction, the sulfite ion is oxidised as follows.

$$SO_3^{2-}(aq) + H_2O(l) \rightarrow SO_4^{2-}(aq) + 2H^+(aq) + 2e$$

What is the new oxidation number of the metal in the salt if its original oxidation number was +3?

A +1 **B** +2 **C** +4 **D** +5

Answer: B

Amount of sulfite ions = $\frac{25}{1000} \times 0.10$ = 0.0025 mol

Amount of metallic salt = $\frac{50}{1000} \times 0.10$ = 0.005 mol

Method 1

Let x be the new oxidation no of metal in salt.

[R]: $M^{3+} + (3-x)e \rightarrow M^x$

Since moles of electrons gained = moles of electrons lost in a redox reaction,

$\frac{3-x}{2} = \frac{0.0025}{0.005}$ x = +2

Method 2

2 mol of metallic salt reacts with 1 mol of SO_3^{2-}

2 mol of metallic salt gains 2 mol of e^- (since 1 mol of SO_3^{2-} loses 2 mol of e^-)

1 mol of metallic salt gains 1 mol of e^-

Final O.N. = +3 + 1
= +2

3 Which particle would, on losing two electrons, have a half–filled p subshell?

A Ga^-

B Se^-

C Te^+

D As^{2+}

Answer: B

Ga^-: [Ar] $3d^{10} 4s^2 4p^2$; on losing two electrons, there will be 0 electron in p subshell.

Se^-: [Ar] $3d^{10} 4s^2 4p^5$; on losing two electrons, there will be 3 electrons in p subshell (half-filled).

Te^+: [Kr] $4d^{10} 5s^2 5p^3$; on losing two electrons, there will be 1 electron in p subshell.

As^{2+}: [Ar] $3d^{10} 4s^2 4p^1$; on losing two electrons, there will be 0 electron in p subshell.

4 The successive ionisation energies (I.E.) of two elements, **B** and **C**, are shown below:

I.E. / kJ mol^{-1}	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**
B	1000	2252	3357	4556	7004	8496	27107	31719
C	578	1817	2745	11577	14842	18379	23326	27465

What is the likely formula of the compound formed when **B** and **C** reacts together?

A B_2C_3

B B_3C_2

C BC_3

D B_3C

Answer: B

For element **B**: biggest increase between 6th and 7th ionisation energy.
(Largest difference in IE between 6th and 7th I.E.)
7th electron is removed from the inner quantum shell which is closer to the nucleus.
Thus the element has 6 valence electrons.
Element **B** belongs to **Group 16.**

For element **C**: biggest increase between 3rd and 4th ionisation energy.
(Largest difference in IE between 3rd and 4th I.E.)
4th electron is removed from the inner quantum shell which is closer to the nucleus.
Thus the element has 3 valence electrons.
Element **C** belongs to **Group 13**.

So the likely formula of the compound formed is **B_3C_2.**

5 Molecular dimerisation can be described as the process in which two identical molecules combine to give a single product.

Examples of dimers are: Al_2Cl_6, N_2O_4 and $(CH_3CO_2H)_2$.

Which of the following descriptions about the above dimers is **incorrect**?

A Hydrogen bonds hold the CH_3CO_2H molecules together in the dimer.

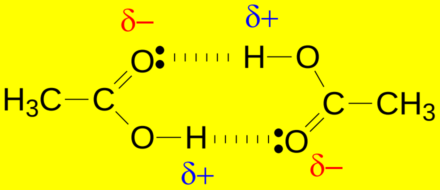
B Each aluminium atom is surrounded by four chlorine atoms in Al_2Cl_6.

C All the nitrogen–oxygen bonds in N_2O_4 are of equal length.

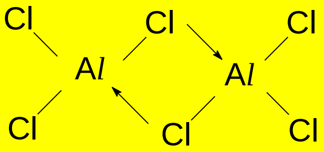
D Al_2Cl_6 is a planar molecule.

Answer: D

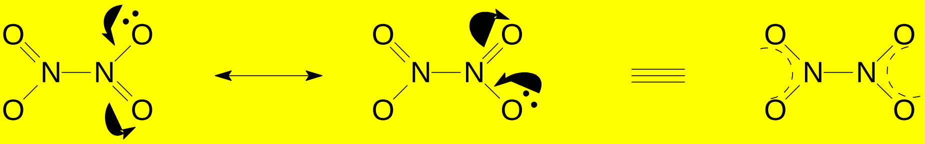
Statement A is correct.



Statement B is correct.



Statement C is correct.



Statement D is **incorrect**. as Al_2Cl_6 is not a planar structure. It is tetrahedral about each Al.

6 Which of the following observations can be explained by intermolecular hydrogen bonding?

1. Ammonia (NH_3) has a higher boiling point than methane (CH_4).
2. Water has a lower density at 0 °C than at 25 °C.
3. Formation of H_3O^+ from water.

A 1,2 and 3

B 1 and 2 only

C 2 and 3 only

D 1 only

Answer: B

Option 1: Ammonia has <u>intermolecular hydrogen bonding</u> while methane only has intermolecular id−id. More energy is required to overcome the stronger intermolecular hydrogen bonding and thus, ammonia has a higher boiling point than methane.

Option 2: In ice, <u>each H_2O molecule is hydrogen−bonded to four other H_2O molecules</u> in a tetrahedral arrangement, giving rise to an <u>open structure</u>. Hence having a lower density.

Option 3: H_3O^+ is formed via <u>dative bonding</u> between water and H^+.

7 Melphalan is a drug used in chemotherapy. When dissolved in blood, the decrease in its concentration has a constant half–life of 90 minutes.

A 100 mg melphalan tablet is dissolved in 4.0 dm^3 blood.

What is the concentration of melphalan in the blood six hours later?

A 1.56 mg dm^{-3}

B 3.13 mg dm^{-3}

C 12.5 mg dm^{-3}

D 25.0 mg dm^{-3}

Answer: A

$[\text{melphalan}]_{\text{initial}} = 100 / 4 = 25 \text{ mg dm}^{-3}$

No of half–lives = $(6\times60) / 90 = 4$

Using $C/C_o = (1/2)^n$
$[\text{melphalan}]_{\text{6 hours later}} / [\text{melphalan}]_{\text{initial}} = (1/2)^4$
$[\text{melphalan}]_{\text{6 hours later}} / 25 = (1/2)^4$
$[\text{melphalan}]_{\text{6 hours later}} = 1.56 \text{ mg dm}^{-3}$

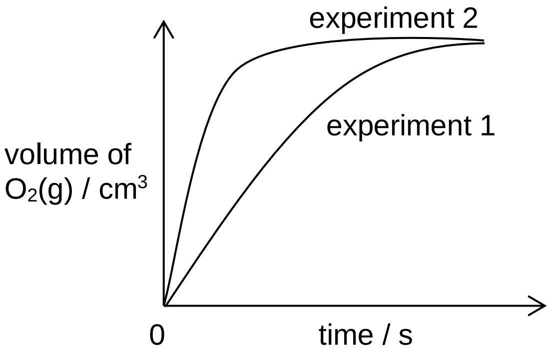
8 Hydrogen peroxide slowly decomposes at room temperature.

$$2H_2O_2 \longrightarrow 2H_2O + O_2$$

Two experiments were performed to study the effects of adding lead(IV) oxide on the decomposition of 1.5 mol dm^{-3} hydrogen peroxide at constant temperature.

Experiment 1: 20 cm^3 of hydrogen peroxide.
Experiment 2: 20 cm^3 of hydrogen peroxide and 1.0 g of lead(IV) oxide.

At the end of the experiment 2 the mixture was filtered and 1.0 g of lead(IV) oxide was recovered.



Which row is correct?

	value of rate constant	activation energy
A	equal in experiment 1 and 2	higher in experiment 1
B	equal in experiment 1 and 2	higher in experiment 2
C	higher in experiment 2	higher in experiment 1
D	higher in experiment 2	higher in experiment 2

Answer: C

Since rate of production of O_2 is faster in experiment 2 and lead(IV) oxide is recovered at the end of the experiment, lead(IV) oxide is a catalyst that speeds up the rate of the reaction.

A catalyst increases the reaction rate by providing a different reaction pathway which has a lower activation energy (E_a).

Since $k = A\, e^{-Ea/RT}$, a lower E_a will decrease the value of rate constant k.

Hence, experiment 2 has a lower E_a and higher k.

9 The values for the standard enthalpy change of combustion of hydrogen and the standard enthalpy change of formation of hydrogen peroxide are –285.8 kJ mol^{-1} and –187.8 kJ mol^{-1} respectively.

What is the standard enthalpy change for this reaction?

$$2H_2O(l) + O_2(g) \rightarrow 2H_2O_2(l)$$

A –98 kJ mol^{-1}

B –196 kJ mol^{-1}

C +98 kJ mol^{-1}

D +196 kJ mol^{-1}

Answer: D

Note that the ΔH_c (H_2) = ΔH_f (H_2O)

Using the formula, $\Delta H_r = \Sigma\, n\, \Delta H_f$ (products) – $\Sigma\, m\, \Delta H_f$ (reactants)
$\Delta H_r = 2\Delta H_f(H_2O_2) - [2\Delta H_f(H_2O) + \Delta H_f(O_2)]$
$= 2(-187.8) - [2(-285.8) + 0]$
$= \underline{+196 \text{ kJ mol}^{-1}}$

10 In vehicles such as cars, internal combustion engines convert the chemical energy in fuels into kinetic energy. The following reaction takes place in an internal combustion engine.

$$2C_8H_{18}(l) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$$

What are the signs for ΔH, ΔS and ΔG for the above reaction?

	ΔH	ΔS	ΔG
A	+	–	+
B	+	+	–
C	–	+	+
D	–	+	–

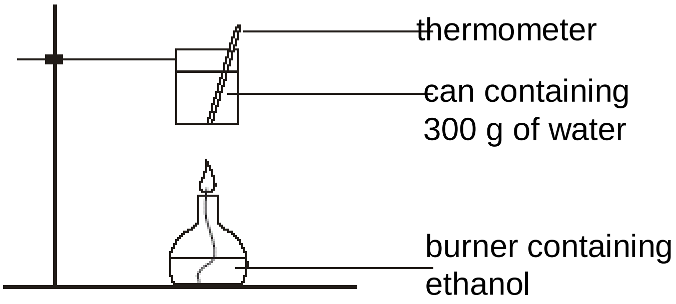
Answer: D

Combustion of fuel is an <u>exothermic</u> process, so ΔH is –ve.
(there is no need to calculate)

Δn_{gases} = (16 + 18) – 25 = 9. Hence, ΔS is +ve.

$\Delta G = \Delta H - T\Delta S$ is –ve for all T.

11 An experiment was conducted to determine the efficiency of the heating of a can of water using a spirit burner.



The following data were recorded:

Mass of ethanol burnt = m g
Change in temperature of water = ΔT °C

You are also given that:

Relative molecular mass of ethanol = 46.0
Enthalpy change of combustion of ethanol = -1370 kJ mol^{-1}
Specific heat capacity of water = c J g^{-1} K^{-1}

Which expression below gives the efficiency of this heating process?

A $\dfrac{300 \times c \times \Delta T \times 46.0}{m \times 1370 \times 1000} \times 100\%$

B $\dfrac{m \times c \times \Delta T \times 46.0}{300 \times 1370 \times 1000} \times 100\%$

C $\dfrac{300 \times c \times \Delta T \times 46.0}{m \times 1370} \times 100\%$

D $\dfrac{m \times 1370 \times 1000}{300 \times c \times \Delta T \times 46.0} \times 100\%$

Answer: A

Q' = 300 x c x ΔT

$\Delta H = \dfrac{Q}{m/46.0}$ ➔ $Q = \dfrac{\Delta H \times m}{46.0}$

$Q' = \dfrac{x}{100} \times Q$

$300 \times c \times \Delta T = \dfrac{x}{100} \times \dfrac{\Delta H \times m}{46.0}$

$x = \dfrac{300 \times c \times \Delta T \times 46.0 \times 100}{\Delta H \times m}$ this implies $x = \dfrac{300 \times c \times \Delta T \times 46.0 \times 100}{1370 \times 1000 \times m}$

Do remember to convert the heat evolved from kJ to J by multiplying by 1000 before finding the % efficiency.

12 When the temperature of a 2.0 dm^3 sample of a gas was changed from 20 °C to ***k*** °C at constant volume, the pressure of the gas was found to have increased from 1 atm to 2 atm.

What is the value of ***k***?

A 10 **B** 40 **C** 313 **D** 586

Answer: C

Using combined Gas Law (and since $V_1 = V_2$)

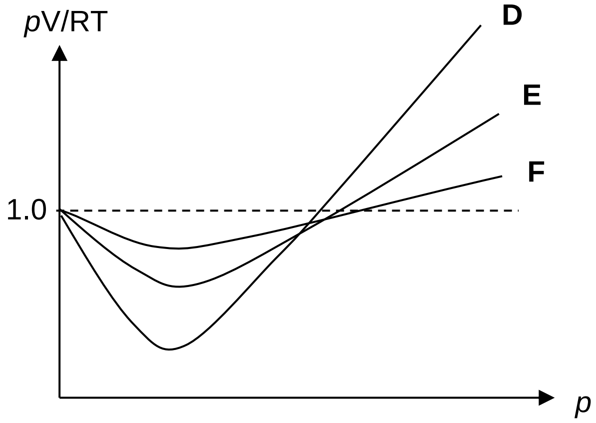
$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

$$\frac{1}{(20+273)} = \frac{2}{(k+273)}$$

$$k + 273 = 586$$

$$k = 313\ ^{o}C$$

13 The value of *pV*/*RT* is plotted against *p* for one mole of each of the three non–ideal gases **D, E** and **F**, where p is the pressure, *V* is the volume and *T* is the temperature of the gas.



Which of the following gases could be **D**, **E** and **F**?

	D	E	F
A	NH_3	H_2O	BF_3
B	H_2O	NH_3	BF_3
C	BF_3	NH_3	H_2O
D	H_2O	BF_3	NH_3

Answer: B

Line corresponding to **D** deviates most from ideality
⇒ intermolecular forces of attraction is the strongest in **D** (and weakest in **F**).

Weaker id–id attractions between non-polar BF_3 molecules than the stronger hydrogen bonding between H_2O molecules and NH_3 molecules. Thus, BF_3 has the least deviation from ideal gas behaviour.
The intermolecular hydrogen bonding in H_2O is more extensive than that in NH_3 thus there is a greater deviation from ideal gas behaviour for H_2O than NH_3.

14 The following process is used to convert methane to hydrogen.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H > 0$$

What will increase the yield of the reaction?

1. Adding argon gas to the mixture but keeping the total pressure constant.
2. Increasing the temperature.
3. Increasing the total pressure by decreasing the total volume at constant temperature.
4. Removing CO and H_2 gas as they are formed but keeping the total volume of the mixture the same.

A 1 and 2 **B** 2 and 4 **C** 1, 3 and 4 **D** 1, 2 and 4

Answer: D

Option 1: An addition of argon (an inert gas) at constant pressure decreases the partial pressures of all the gases*. Position of the equilibrium will shift right favouring the formation of the products.

* Two ways to see it:

- n(total) increases but n(CH_4) etc remains. ∴ partial pressure of each gas decreases ($\frac{n(CH_4)}{n(total)} \times p_{total}$).
- adding more gaseous particles at constant volume would increase the volume of the system. Partial pressures of each gas decreases.

Option 2: Increasing the temperature causes the P.O.E. to shift to the right as the forward endothermic reaction removes some of the added heat.

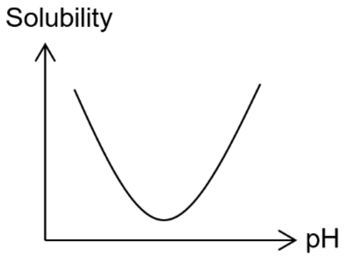
Option 3: Increase in total pressure will cause the P.O.E. to shift left to remove the added pressure as the backward reaction results in a decrease in number of gaseous particles.

Option 4: Removing CO and H_2 causes P.O.E. to shift right to increase the concentration of CO and H_2 or decreases the total pressure of the system, thus P.O.E. shifts right.

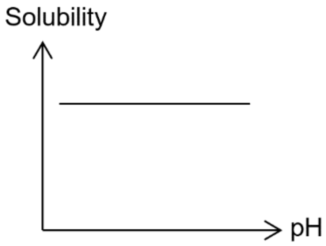
15 CaF_2 is a sparingly soluble salt and is added to a weakly acidic solution of HF. The pH of the solution is adjusted by adding NaOH.

Which diagram shows how the solubility of CaF_2 will vary with the pH of the solution at constant temperature?

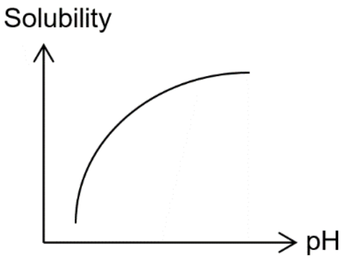
A



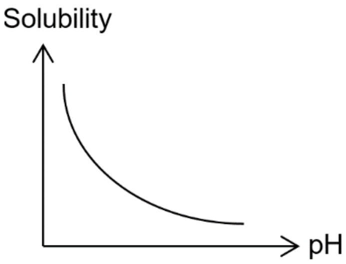
B



C



D



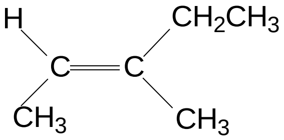
Answer: D

CaF_2 (s) $\rightleftharpoons$ Ca^{2+} (aq) + $2F^{-}$(aq) Eqm 1
HF (aq) $\rightleftharpoons$ H^{+} (aq) + F^{-}(aq) Eqm 2

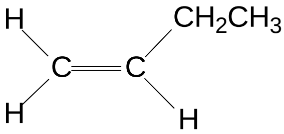
When pH is very high, the H^{+} is neutralised by the OH^{-}, hence eqm 2 is shifted to RHS to produced more F^{-}. This will cause the P.O.E. of Eqm 1 to shift to LHS, reducing the solubility of CaF_2(s)

16 Which of the following compounds react with HBr in an addition reaction to form a major product that is chiral?

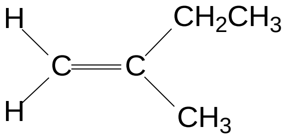
1



2



3



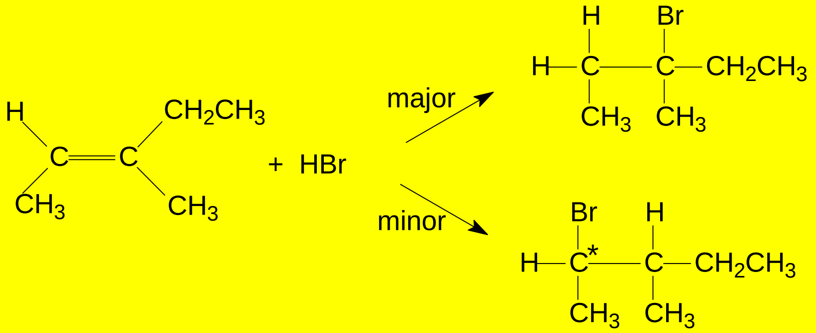
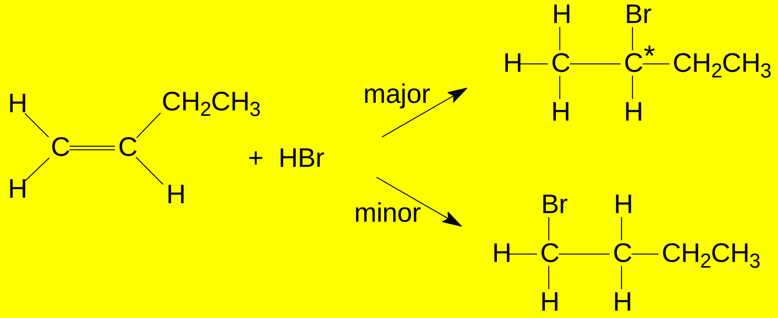
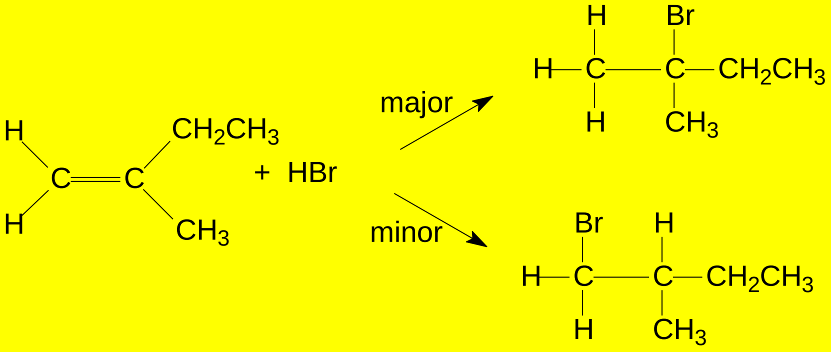
A 1 only

B 2 only

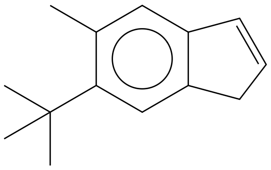
C 1 and 2 only

D 1, 2 and 3

Answer: B

Option 1	
Option 2 – only the major product here has a chiral carbon.	
Option 3	

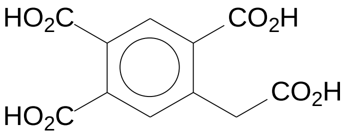
17 Compound **G** reacts with acidified $KMnO_4$ under suitable condition.



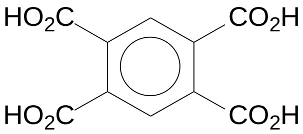
Compound **G**

What is the most likely organic products formed from this reaction?

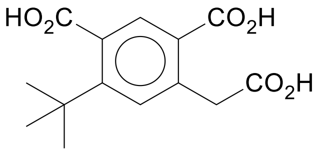
A



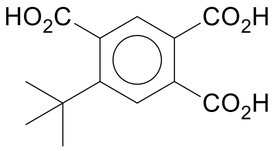
B



C



D



Answer: D

Oxidation of alkene and alkyl side chain of benzene ring will occur.

$–C(CH_3)_3$ is resistant to oxidation due to absence of benzylic H.

18 An enantiomerically pure bromoalkane, RBr, is reacted with aqueous sodium hydroxide. Results of an investigation into the kinetics of this reaction are given below.

experiment number	[RBr] / mol dm^{-3}	[NaOH] / mol dm^{-3}	relative initial rate
1	0.10	0.20	1.00
2	0.20	0.10	2.00
3	0.30	0.20	3.00

Which of the following statements about the reaction are correct?

1 It produces a racemic mixture.

2 It proceeds via a pentavalent transition state.

3 Sodium hydroxide is involved in the rate–determining step of the mechanism.

A 1 only

B 1 and 3

C 2 and 3

D 1, 2 and 3

Answer: A

Using the data provided,
Using Expt 1 and 3, when [RBr] increased 3 times, relative initial rate increased 3 times.
Rate is proportional to [RBr]. Thus, first order with respect to RBr.

Using Expt 1 and 2,

$$\frac{\text{rate}_1}{\text{rate}_2} = \frac{k[0.10][0.20]^n}{k[0.20][0.10]^n}$$

$$\frac{1}{2} = \frac{1[0.20]^n}{2[0.10]^n}$$

solving n = 0 (where n is the order of reaction w.r.t. NaOH)

Thus, Rate = *k* [RBr] which indicates S_N1 mechanism.

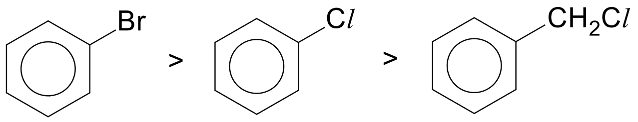
Option 1 is the best choice as an enantiomerically pure RBr will form a carbocation intermediate with planar shape relative to the C+ and forms equimolar of 2 enantiomers (racmic mixture) while options 2 and 3 are more relevant for S_N2.

19 Which sequence shows the correct order of **decreasing** ease of hydrolysis?

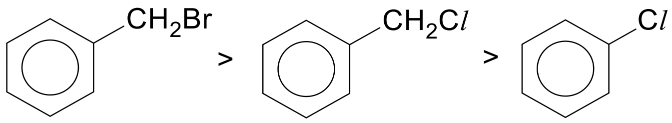
A $CH_3CH_2Cl > CH_3CH_2Br > CH_3CH_2I$

B $(CH_3)_2CHCl > (CH_3)_2CHI > (CH_3)_2CHBr$

C



D



Answer: D

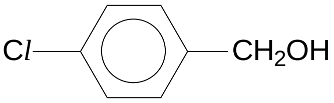
The bond strength of the C–X bond determines the rate of hydrolysis. Aryl halides are resistant to hydrolysis due to the partial double bond between C and X when lone pair of electrons on X delocalised into benzene ring.

20 An organic compound **H** has the following properties:

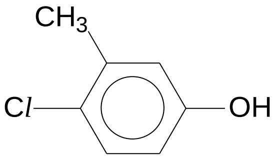
- It has the molecular formula C_7H_7OCl.
- When $Br_2(aq)$ is added to **H**, a white solid, with M_r of 300.3, is formed.
- Warming **H** with $AgNO_3(aq)$ gives a white solid, which is soluble in $NH_3(aq)$.

What is the likely identity of compound **H**?

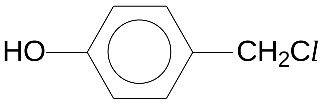
A



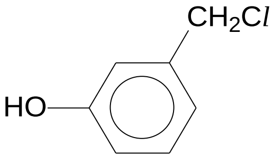
B



C



D

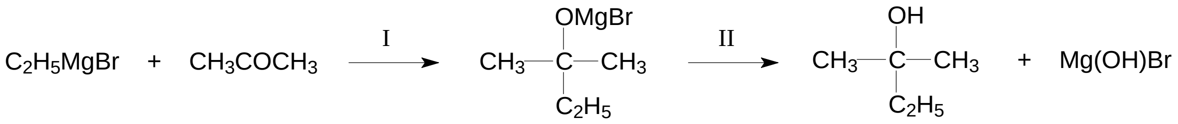


Answer: C

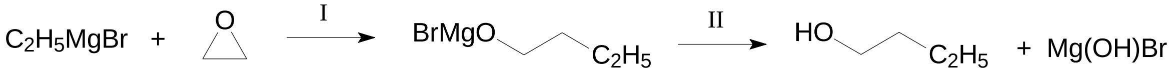
Observation	**Deduction**
molecular formula C_7H_7OCl	From the change in M_r, it can be deduced that 2 H atoms have been <u>substituted</u> by 2 Br atoms. This suggests that one of the 2nd or 4th position wrt phenol in **H** cannot be substituted by Br. **H** is a 2–substituted or 4–substituted phenol. (Narrowed to option **B** and **C**)
$Br_2(aq)$ is added to **H**, a white solid, with M_r of 300.3 $[300.3 - 35.5 = 264.\underline{8} \Rightarrow 2(79.\underline{9})]$	
Warming **H** with $AgNO_3(aq)$ gives a white solid, which is soluble in $NH_3(aq)$	White ppt is AgCl. Cl in **H** is <u>not directly bonded to the benzene ring</u>.

21 Most of the chemistry of magnesium relates to its ionic compounds. However, magnesium does form an important group of covalent compounds which are known as Grignard reagents. Many Grignard reagents, with different alkyl or aryl groups, are widely used in organic syntheses.

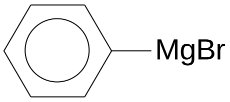
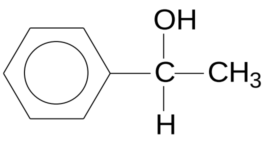
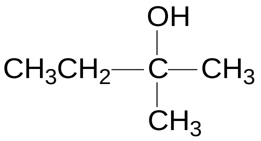
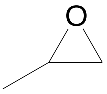
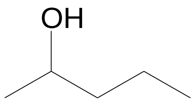
The following reaction schemes show two typical examples of the use of a Grignard reagent.



$$C_2H_5MgBr + CH_3COCH_3 \xrightarrow{I} CH_3C(OMgBr)(C_2H_5)CH_3 \xrightarrow{II} CH_3C(OH)(C_2H_5)CH_3 + Mg(OH)Br$$



Which of the following sets show the correct reactants and products obtained upon undergoing the same reaction scheme?

	reactants	products
1	 + CH_3CHO	 + Mg(OH)Br
2	$CH_3CH_2CH_2MgBr$ + CH_3COCH_3	 $CH_3CH_2C(OH)(CH_3)CH_3$ + Mg(OH)Br
3	CH_3CH_2MgBr + 	 + Mg(OH)Br

A 2 only

B 3 only

C 1 and 2 only

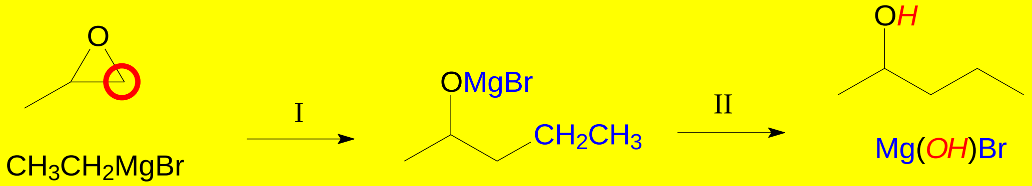
D 1 and 3 only

Answer: D

1 **is correct**. Similar to the above steps, **$-C_6H_5$** and **–MgBr** are added to the carbonyl group of CH_3CHO, followed by hydrolysis of the O–Mg bond to form **C_6H_5**$CH(OH)CH_3$ and **Mg**(*OH*)**Br**.

2 is incorrect. The reactant has a longer carbon chain (additional $-CH_2-$).

3 **is correct**. By observation, an alcohol will be formed when the epoxide reacts with a Grignard reagent. The **$CH_3CH_2^-$** nucleophile will attack the epoxide ring from a less sterically hindered approach (circled in red).

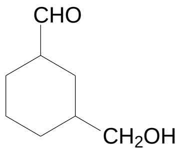


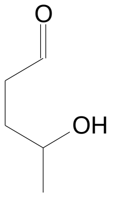
22 When compound **J** is heated with aqueous acidified potassium dichromate(VI), a colour change from orange to green is observed.

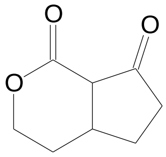
Three tests are carried out on the organic product of this reaction.

test	observation
Fehling's solution	no observation change
2,4–dinitrophenylhydrazine	orange precipitate formed
magnesium ribbon	effervescence

What could be compound **J**?

1 

2 

3 

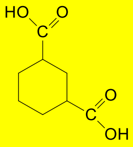
A 1, 2 and 3

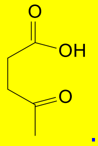
B 1 and 2

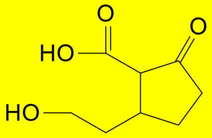
C 2 and 3

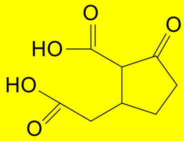
D 2 only

Answer: C

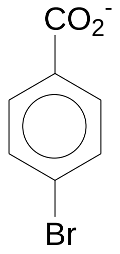
Option 1 product is  it has no carbonyl group to react with 2,4–DNPH.

Option 2 product is  . It will give the observations as stated.

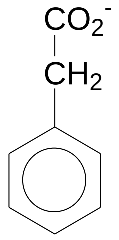
Option 3 compound **J** undergo acidic hydrolysis first to produce  .

The alcohol will then be oxidised to form the carboxylic acid 

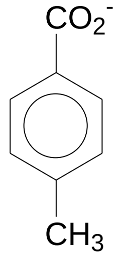
23 Which of the following sequences ranks the given species in order of **decreasing** K_b values?



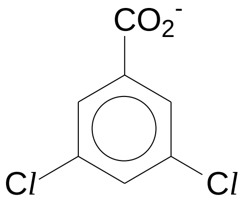
I



II



III



IV

A **III, II, I, IV**

B **II, IV, III, I**

C **II, III, I, IV**

D **IV, I, III, II**

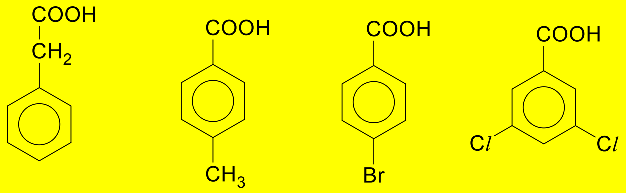
Answer: C

Strength of a base depends on
❶ availability of the lone pair of electrons in forming a dative bond to an acid / proton, or
❷ stability of its conjugate acid.

As it may not be easy to discuss using ❶ here, you may consider using ❷.

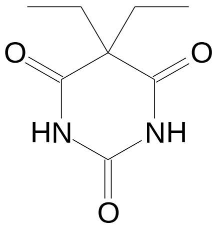
A stronger base will have a weaker conjugate acid (i.e. more stable). Hence, looking at the relative acidity of these carboxylic acids, their conjugate base could be arranged from the highest K_b to the lowest K_b in this order II, III, I, IV.

weakest acid strongest acid



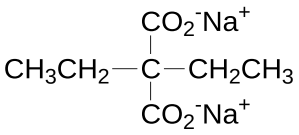
(III, I, IV): substituent(s) on benzene is a deactivating (stronger) or activating group (weaker)
(II) $C_6H_5CH_2CO_2H$ is a weaker acid than $CH_3C_6H_4CO_2H$ because the C atom bonded to the $–CO_2H$ group has different hybridisation state (sp^3 vs sp^2 respectively). sp^3 hybridised C atom exerts stronger electron-donating effect and destabilise the conjugate base more.

24 5,5–diethylbarbituric acid was used as a sleeping aid from 1903 until the mid–1950s.



5,5–diethylbarbituric acid

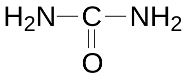
Which of the following is not found among the products of the complete hydrolysis of 5,5–diethylbarbituric acid by aqueous sodium hydroxide?

A 

$$CH_3CH_2-\overset{\displaystyle CO_2^-Na^+}{\underset{\displaystyle CO_2^-Na^+}{C}}-CH_2CH_3$$

B NH_3

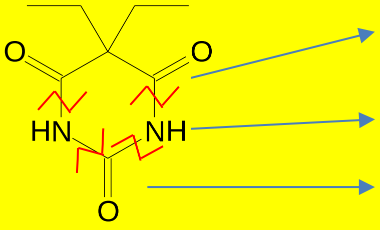
C Na_2CO_3

D 

$$H_2N-\underset{\displaystyle \overset{\|}{O}}{C}-NH_2$$

Answer: D

D cannot be found because the amide bonds present would be hydrolysed!

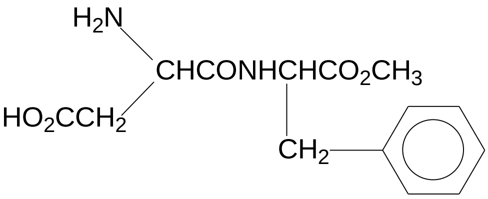


Upon the hydrolysis of the amide groups, neutralisation will occur for the carboxylic acid formed.

NH_3 is formed

CO_3^{2-} is formed (which results in Na_2CO_3)

25 Aspartame is widely used as a sweetener in canned drinks.



Aspartame

Which of the following statement is correct?

A Ethanol is formed when aspartame is reacted with hot aqueous hydrochloric acid.

B Aspartame reacts with 3 mol of cold aqueous sodium hydroxide.

C Aspartame reacts with 2 mol of hot aqueous hydrochloric acid.

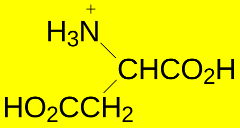
D Aspartame give yellow precipitate with alkaline aqueous iodine.

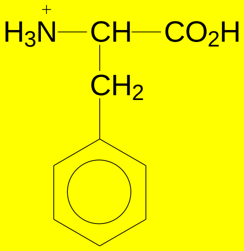
Answer: C

A: Methanol and not ethanol is formed.

B $-CO_2H$ group in aspartame reacts with 1 mol of cold aqueous sodium hydroxide as base-catalysed hydrolysis of ester and amide can only occur under hot condition.

C: One mole is used to react with the $-NH_2$ formed from hydrolysis of the amide bond, while the 2nd mole reacts with the basic $-NH_2$ group.





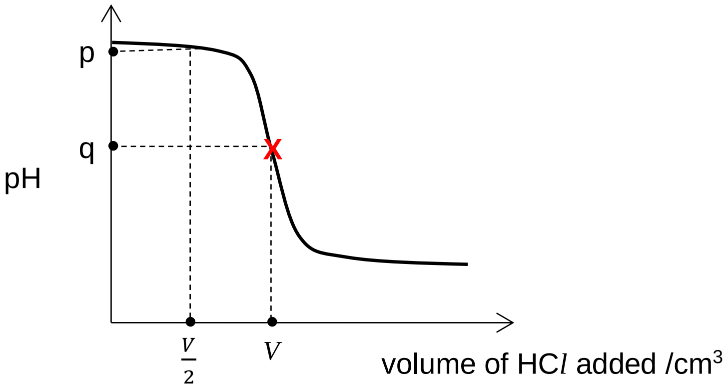
$HOCH_3$

D: No yellow ppt is produced as there is absence terminal methyl–alcohol or methyl–ketone.

26 Ethylamine, $CH_3CH_2NH_2$, is a weak monoprotic base with the following K_b value.

$K_b = 4.5 \times 10^{-4}$ mol dm^{-3}

25.0 cm^3 of 0.10 mol dm^{-3} aqueous $CH_3CH_2NH_2$ was titrated with 0.20 mol dm^{-3} dilute HC*l*. The titration curve obtained is shown below.



Which of the following sets of values correspond to the points in the diagram?

	V	p	q
A	12.5	10.7	less than 7
B	25.0	10.7	more than 7
C	12.5	3.3	less than 7
D	25.0	3.3	more than 7

Answer: A

$CH_3CH_2NH_2 + HCl \rightarrow CH_3CH_2NH_3^+Cl^-$
Amt of $CH_3CH_2NH_2 = \frac{25}{1000} \times 0.10 = 0.0025$ mol
V, Volume of HC*l* = 0.0025 ÷ 0.20 = 0.0125 dm^3 = **12.5 cm^3**

$CH_3CH_2NH_3^+$ salt formed undergoes hydrolysis, producing H_3O^+

$$CH_3CH_2NH_3^+ + H_2O \rightleftharpoons CH_3CH_2NH_2 + H_3O^+$$

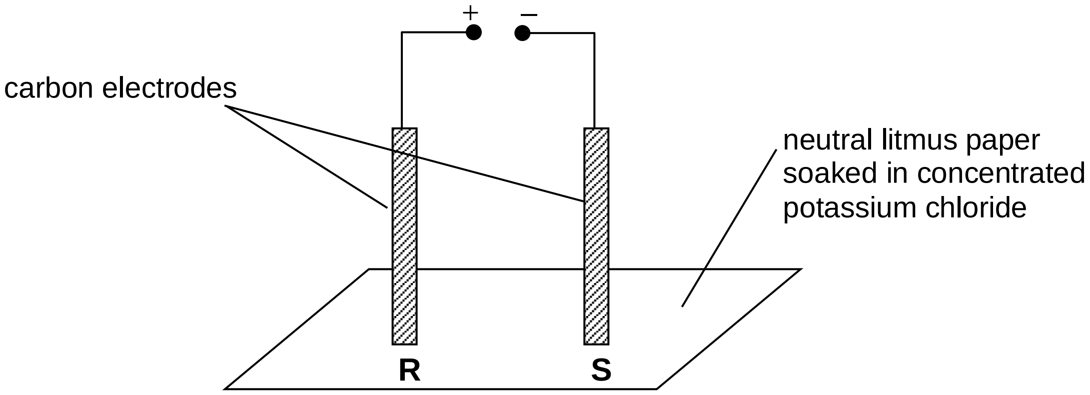
Thus, $[H_3O^+]$ is more than $[OH^-]$, pH of solution at **q** is **less than 7**

At $\frac{V}{2} = \frac{12.5}{2}$ **cm^3**, $[CH_3CH_2NH_2]_{left} = [CH_3CH_2NH_3^+]_{formed}$
maximum buffer capacity occurs
pOH = pK_b
= 3.3

pH = 14 – pOH
= 14 – 3.3
= **10.7**

27 *Use of the Data Booklet is relevant to this question*.

A direct current is passed through the apparatus shown in the diagram below.



What are the colours observed at positions **R** and **S** after some time?

	R	**S**
A	blue	red
B	red	blue
C	white	blue
D	blue	white

Answer: C

Firstly, students must figure out that the positive terminal is connected to the anode while the negative terminal is connected to the cathode (since electrons always flow from anode to cathode)

Electrode at **R** is the anode
Selective discharge of chloride will occur. $2Cl^{-} \rightarrow Cl_2 + 2e$
Cl_2 formed will bleach the litmus. (from *Data Booklet*)
[FYI: $Cl_2 + H_2O \rightarrow HCl + HClO$; HC*l* turns the blue litmus red before HOC*l* bleaches it]

Electrode at **S** is the cathode. Reduction of water will occur.
$2H_2O + 2e \rightarrow H_2 + 2OH^{-}$
Since OH^{-} is produced. Region at **Y** will turn blue.

28 *Use of the Data Booklet is relevant to this question*.

An excess of sulfur dioxide, SO_2, is bubbled into a warm solution containing VO_2^+ ions. What will be the final oxidation state of vanadium?

A +2

B +3

C +4

D +5

Answer B

$SO_4^{2-} + 4H^+ + 2e \rightleftharpoons \underline{\mathbf{SO_2}} + 2H_2O$ +0.17 V
$\underline{\mathbf{VO_2^+}} + 2H^+ + e \rightleftharpoons VO^{2+} + H_2O$ +1.00 V
$E_{cell} = 1.00 - 0.17 = +0.83$ (>0, reaction feasible)

$SO_4^{2-} + 4H^+ + 2e \rightleftharpoons \underline{\mathbf{SO_2}} + 2H_2O$ +0.17 V
$\underline{\mathbf{VO^{2+}}} + 2H^+ + e \rightleftharpoons V^{3+} + H_2O$ +0.34 V
$E_{cell} = 0.34 - 0.17 = +0.17$ (>0, reaction feasible)

$SO_4^{2-} + 4H^+ + 2e \rightleftharpoons \underline{\mathbf{SO_2}} + 2H_2O$ +0.17 V
$\underline{\mathbf{V^{3+}}} + e \rightleftharpoons V^{2+}$ – 0.26 V
$E_{cell} = -0.26 - 0.17 = -0.43$ (<0, reaction not feasible)

Final oxidation state of V is $\underline{+3}$.

29 The enthalpy change of fusion of a solid is defined as the amount of energy, in J or kJ, required to melt one mole of a solid at its melting point.

The table shows the enthalpy change of fusion of four successive elements, *W* to *Z*, in the third period (sodium to argon) of the Periodic Table.

element	*W*	*X*	*Y*	*Z*
enthalpy change of fusion / kJ mol^{-1}	10.8	46.4	0.6	1.4

Which sequence of elements is represented by *W* to *Z*?

	W	*X*	*Y*	*Z*
A	A*l*	Si	P	S
B	Na	Mg	A*l*	Si
C	P	S	C*l*	Ar
D	Si	P	S	C*l*

Answer: A

enthalpy change of fusion of *X* is the highest and subsequently *Y* and *Z* decreases indicating *Y* and *Z* have a simple molecular structure. This means *X* can be Si and *W* is A*l*.

Z has a higher enthalpy change of fusion than *Y* which coincides with the observations of *Y* being P and *Z* being S. Sulfur exist as S_8 while phosphorous exist P_4.

W is A*l* *X* is Si *Y* is P and *Z* is S

30 Which of the statements about Group 2 elements is correct?

A The reducing power decreases down the group.

B The ionic radius increases down the group.

C The electronegativity increases down the group.

D The reactivity with water decreases down the group.

Answer: B

Down the group, reducing power increases, electronegativity decreases and reactivity with water increases

END OF PAPER