2020 TJC Promo H2 Chemistry MCQ Worked Solutions

1 Answer: B

Since J has a larger angle of deflection than $^{16}O^{2-}$, it would have a greater charge/mass ratio than $^{16}O^{2-}$.

2 Answer: C

P^+ : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$

Cu^{3+}: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8$

Ca: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$

S: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

3 Answer: A

No. of moles of ethanol molecules = $\frac{23}{24+16+6}$ = 0.500 mol

No. of moles of atoms in g of ammonia = $\frac{2.125}{17}$ x 4 = 0.500 mol

No. of moles of molecules in 11.35 dm^3 of sulfur dioxide = $\frac{11.35}{22.7}$ = 0.500 mol

No. of moles of sodium ions = $\frac{250}{1000}$ x 2 x 2 = 1.00 mol

4 Answer: B

	V	C	H	O
%	19.21	45.3	5.29	30.2
A_r	50.9	12	1	16
Amt	0.377	3.77	5.29	1.88
ratio	1	10	14	5

Empirical formula = $VC_{10}H_{14}O_5$

Z = (5 – 1)/2 = 2

5 Answer: A

$H_2S \rightarrow S + 2H^+ + 2e$
$SO_2 + 4H^+ + 4e \rightarrow S + 2H_2O$
Reacting ratio: $2H_2S \equiv SO_2$

6 Answer: D

Bond angle 1 is around a sp^2 carbon atom with 3 bp, 0 lp = 120°

Bond angle 2 is around a sp^3 carbon atom with 4 bp, 0 lp = 109.5°

Bond angle 3 is around a N-atom with 3 bp, 1 lp = 107°

7 Answer: C

There are no hydrogen bonds existing between methanal molecules. Methanal is a polar hence pd-pd interactions exist between methanol which is stronger than id-id interactions between non polar ethane molecules.

8 Answer: A

ΔH_r= 4(–241.8) – 2(50.6) – (9.2) = <u>–1077.6 kJ mol^{-1}</u>

9 Answer: D

√ 2: Combustion reactions are exothermic in nature.

√ 4: The stoichiometric ratio of sodium oxide is defined as 1 and sodium oxide is formed from its elements.

10 Answer: B

Heat absorbed by water
$= 80.2 \times \frac{80}{100}$ = 64.16 kJ = 64 160 J

Heat absorbed by water = mcΔT
64 160 = m (4.18)(80 – 25)

Mass of water = 279 g

11 Answer: D

Since K_c remains constant, there is no change in position of equilibrium when temperature changes and the enthalpy change, ΔH is zero.

12 Answer: B

$K_c = [NH_3]^2[H_2SO_4] = 2.57 \times 10^{-5}$

$(2x)^2(x) = 2.57 \times 10^{-5}$ hence $x = 0.0186$

13 Answer: B

√ 1 Vol of O_2 (product) increases from 0 to 50cm^3 (½ of max vol) in 20 s
Vol of O_2 (product) increases from 50 to 75cm^3 (½ of maxi vol to ¾ of max vol) in 20 s
half-life is a constant at 20 s.

√ 2 Since half-life is a constant at 20s, the reaction is first order w.r.t. $[H_2O_2]$.

14 Answer: C

Both k_f and k_b will increase while K_c remains constant as K_c is only temperature dependent.

15 Answer: A

When p increases $\frac{5}{2}$ times, the V should decrease $\frac{5}{2}$ times to 38.4 cm^3 if the gas is ideal.

But V of the gas only decreases to 46 cm^3 ➔ $V_{real} > V_{ideal}$

16 Answer: B

$(0.68)V_T = (0.7)(1.0) + (0.5)(2.5) + (1.0)(1.5)$
$V_T = 5.074$ dm^3

Vol of connecting tube = 5.074 – (1.0 + 2.5 + 1.5) = 0.074 dm^3

17 Answer: C

An electrophile is an electron pair acceptor.

They are positively or partial positively charged.

They are attracted to electron rich sites or regions with high electron density.

18 Answer: A

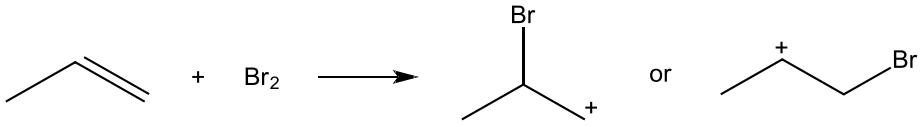
H• radicals are not formed in free radical substitution reactions.
Hence H_2 will not be formed.

HC*l* is formed in the propagation step.

CH_2Cl_2 is formed from further substitution of CH_3Cl.

CH_3CH_2Cl is formed from $\bullet CH_3$ and $\bullet CH_2Cl$ in a termination step.

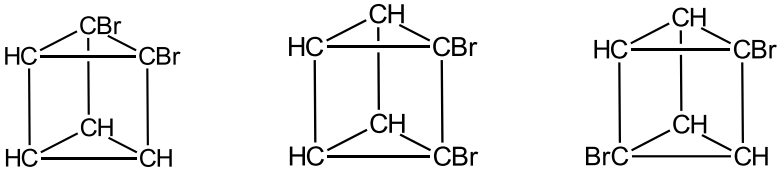
19 Answer: D



20 Answer: B

Prismane undergoes free radical substitution with bromine in uv light. 2 hydrogen atoms are substituted with bromine atoms.

There are 3 possible constitutional isomers:



SECTION B (STRUCTURED)

1 (a) (i) Comparing expt 1 & 2, when [NO] is constant and $[O_2]$ doubles,

rate of reaction doubles. The order of reaction wrt O_2 is 1.

(ii) Comparing expt 2 & 3, when [NO] doubles and $[O_2]$ constant,

rate increases by 4 times. The order of reaction wrt NO is 2.

(iii) Rate = $k\,[O_2][NO]^2$

(iv) [NO] = 3.90×10^{-2} mol dm^{-3}

(b) (i) $K_c = \frac{[NO]^2}{[NO]^2[O_2]}$

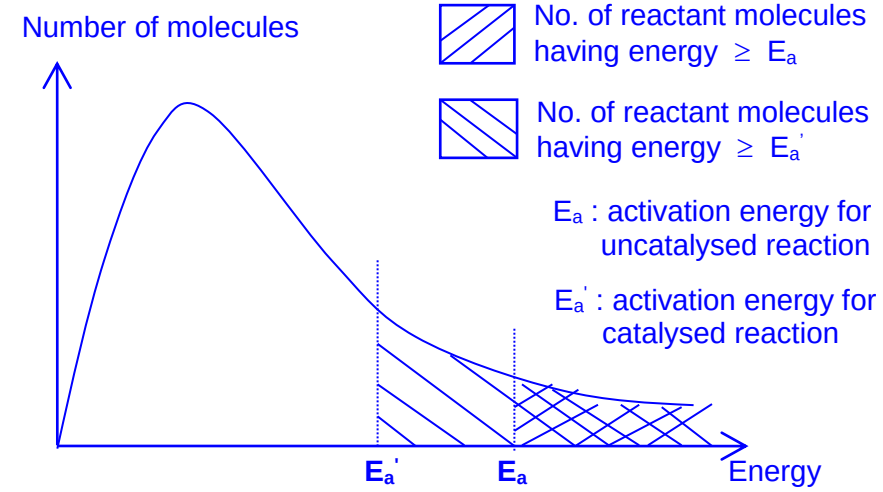
$= \frac{[\frac{0.02}{2}]^2}{[\frac{0.44}{2}]^2[\frac{0.34}{2}]}$

$= 0.0122$ mol^{-1} dm^3

(ii) By *Le Chatelier's Principle*, the equilibrium position will shift left *OR* towards the backward reaction in order to produce greater no of moles of gas to increase pressure.

Amount of NO_2 decreases and the amount of NO and O_2 increases.

2 **(a)** **(i)** ✓



A catalyst provides an alternative pathway with lower activation energy or E_a . There are more molecules with energy greater than or equal to the lowered E_a, Frequency of effective collisions increases Rate constant increases and hence rate of reaction increases.

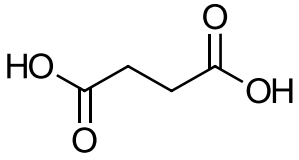
(ii) Iron is a heterogeneous catalyst that provides a surface for H_2 and N_2 to be adsorbed. This increases the concentration of H_2 and N_2 at the catalyst surface. The intramolecular OR covalent bonds in H_2 and N_2 are weakened. Product NH_3 desorbed from the iron surface and diffuses away.

(iii) Porous solid provides a larger surface area for catalysis.

(b) **(i)** IC*l* is polar (has a permanent dipole) hence the electron rich C=C bond attacks the Iδ+ in ICl more readily.

(ii) Elimination Alcoholic KOH, heat

(iii)



3 **(a)** **(i)** Element Y is in Group 16.

Large increase in IE when the 7th electron is removed

implies that 7th electron is removed from the inner shell

(ii) I

(iii) J has larger nuclear charge as it has more protons.

Due to its additional electron shell, J has greater screening effect.

The valence electrons of J are further from the nucleus and less

strongly attracted by the nucleus. Less energy is required to

remove the electron of J than that of B.

(b) **(i)** $NO_3^- + Sn^{2+} + 2H^+ \rightarrow NO_2^- + Sn^{4+} + H_2O$

(ii) No. of moles of $S_2O_3^{2-}$ = 0.12 × 0.022
= 0.00264 mol

No. of moles of Sn^{4+} = 0.00264/2
= 0.00132 mol

No. of moles of Sn^{2+} in 50 cm^3 solution = 0.00132 × 50/10
= 0.00660 mol

(iii) Percentage purity of tin = (0.00660 x 118.7)/2.5 x 100% = 31.3%

4 **(a)** **(i)** Carbon **1**: sp

Carbon **2**: sp^3

(ii) Carbon **1**: Linear, 180°

Oxygen: Bent, 104.5°

(b) **(i)** $C_4H_6O(l) + 5O_2(g) \rightarrow 4CO_2(g) + 3H_2O(l)$

(ii) Energy taken in for bond breaking
= 6(410) + 1(350) + 1(840) + 2(360) + 5(496)
= 6850 kJ mol^{-1}

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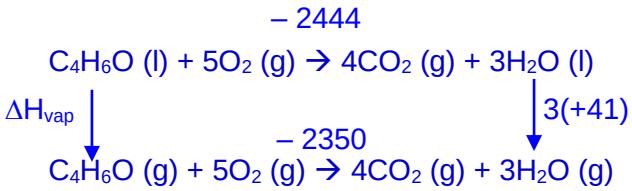
Energy given out for bond forming
= 8(805) + 6(460)
= 9200 kJ mol^{-1}

ΔH_c = 6850 – 9200 = –2350 kJ mol^{-1}

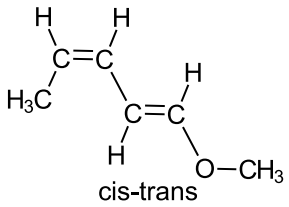
(iii) Compound X is a liquid whereas the bond energies in Data Booklet correspond to breaking covalent bonds in the gaseous state.

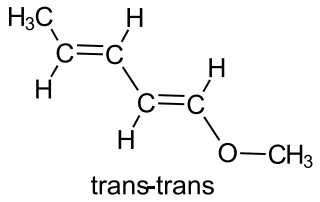


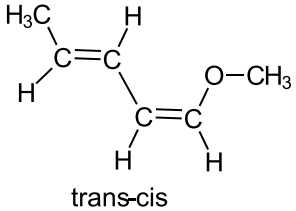
ΔH_{vap} = (–2444) + 3(+41) – (–2350**)** **=** +29.0 kJmol^{-1}

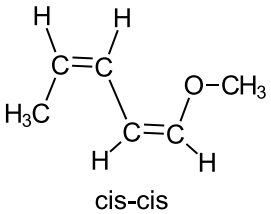
(c) **(i)** Compound Y exhibits cis-trans isomerism as there are restricted rotation about the carbon-carbon double bonds and each carbon of the double bond is bonded to 2 different substituents.

(ii) Total number of stereoisomers: 4









2020 TJC Promo Section C Suggested Answers

Section C Free Response

1 **(a)** $2H_2S + 2O_2 \rightarrow S + SO_2 + 2H_2O$

(b) **(i)** $\Delta H_c^{\ominus}$, is the heat energy evolved when one mole of the substance is completely burnt in excess oxygen at 298 K and 1 bar.

(ii) $\Delta H_c = \frac{(-242)+(-283)}{2} = -262.5 = \underline{-263 \text{ kJ mol}^{-1}}$

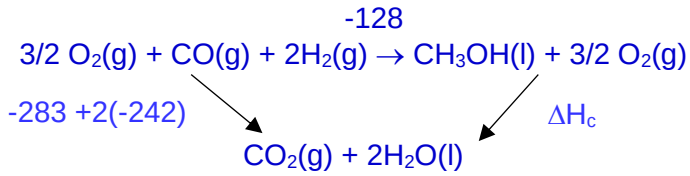
(iii) No. of moles of methane = 1500/890 = 1.69 mol
Volume of methane = 1.69 x 24 = 40.6 dm^3

No. of moles of water gas = 1500/262.5 = 5.71 mol
Volume of water gas = 5.71 x 24 = 137 dm^3

(iv) From (b)(iii), a smaller volume of methane (in natural gas) is required to produce the same amount of energy.

Water gas contains highly toxic carbon monoxide gas that binds strongly to haemoglobin in blood. OR
Water gas contains hydrogen gas which is highly explosive. OR
Water gas must be synthetically produced (using superheated steam) increases costs and resources needed.

(c) **(i)**



$\Delta H_c = -639 \text{ kJ mol}^{-1}$

(ii) Both have simple molecular structures. Hydrogen bonding present between methanol molecules is stronger and requires more energy to break than the weak instantaneous dipole-induced dipole interactions in methane molecules. Methanol has a larger electron cloud than methane which is more easily distorted. This causes the id-id forces of attraction to be stronger between methanol molecules.Thus, boiling point of methanol is higher and it exists as a liquid.

(d) **(i)** $\Delta H_n^{\ominus}$, is the enthalpy change when an acid and a base react under infinitely dilute conditions to form one mole of water at 298 K and 1 bar.

(ii) Limiting reagent is NaOH(aq).

No. of moles of water produced
$= \frac{30}{1000} \times 1 = \underline{0.0300 \text{ mol}}$

(iii) $\Delta H = -\frac{(30+30)\times 4.18\times 6.8}{0.03} = -56.8 \text{ kJ mol}^{-1}$

No. of moles of water produced in second reaction
$= \frac{15}{1000} \times 2 = 0.03 \text{ mol}$

$\Delta H = -\frac{(15+15)\times 4.18\times \Delta T}{0.03}$ = -56.8 kJ mol^{-1}

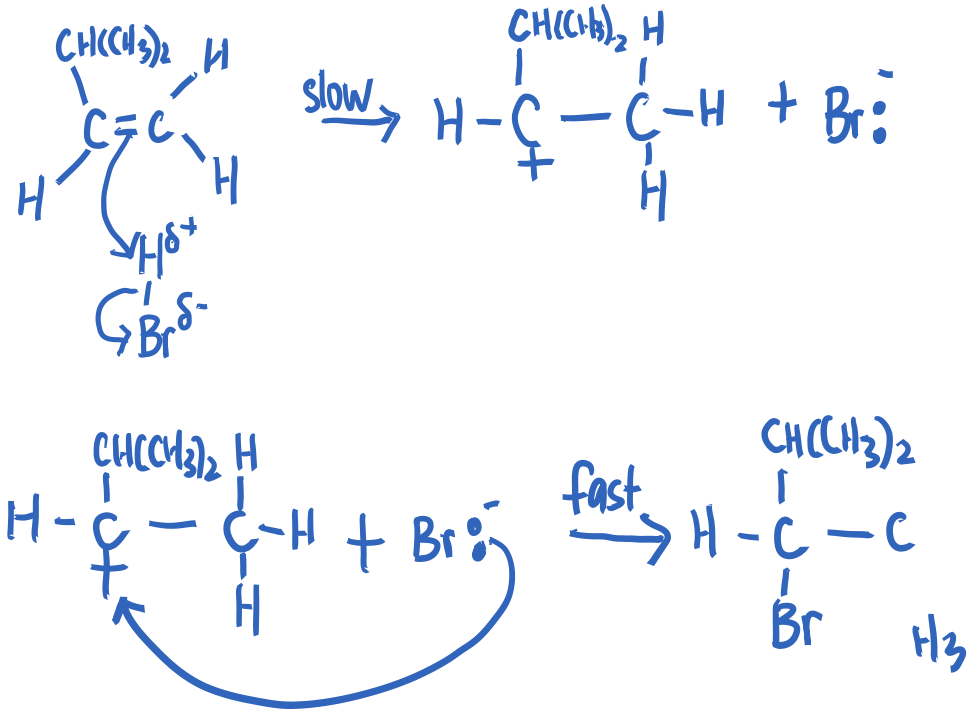
ΔT = 13.6 °C

(iv) No. of moles of remaining H_2SO_4 = 0.03 – 0.015 = 0.015 mol

No. of moles of H_2SO_4 in 25 cm^3 of diluted solution
= 0.015/4 = 0.00375 mol

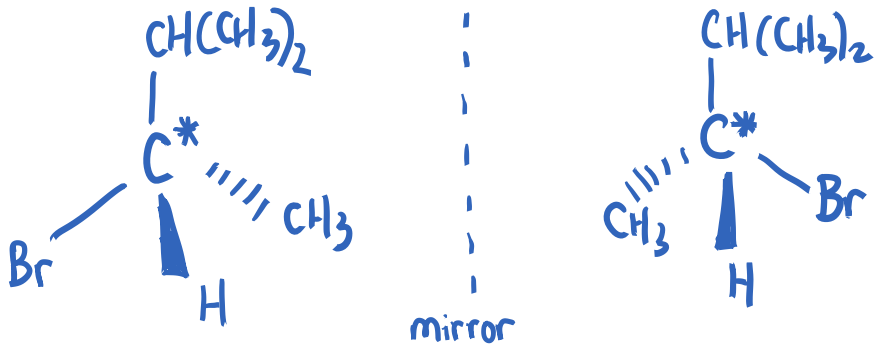
[KOH] =(0.00375 x 2) 0.0075 ÷ (18.60/1000) = 0.403 mol dm^{-3}

2 (a) (i) Electrophilic addition



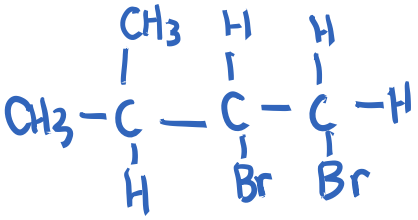
(ii) In step 2 of the mechanism, there is planar arrangement about the carbon with the positive charge. The carbocation can be attacked by Br^- either from the top or the bottom of the plane, with equal probability.

This leads to the formation of a pair of enantiomers which are non-superimposable (as there is a chiral centre).



(iii) Optically inactive

(iv)



Decolourisation of reddish brown bromine

(v) The entropy will increase as the gaseous state has more ways to arrange the particles as compared to the liquid state.

(b) **(i)** Pressure = $1 \times 8.31 \times 298 / 0.25 \times 10^{-3} = 9.91 \times 10^{6}$ Pa

(ii) $p = (1)(8.31)(298)/(0.25 \times 10^{-3} – 1 \times 4.28 \times 10^{-5}) – (1)^2(0.228)/(0.25 \times 10^{-3})^2$

$= 8.30 \times 10^{6}$ Pa

(iii) There is significant instantaneous dipole–induced dipole interactions between CH_4 molecules.

(c) **(i)** $\Delta H_{soln}^{\ominus} = (–390) + (–384) – (–779) = +5.00$ kJ mol^{-1}

(ii) Mg^{2+} has a higher charge and smaller ionic radius OR has a higher charge density as compared to Na^{+}, hence a large magnitude of hydration energy.

(iii) $\Delta G_{soln}^{\ominus}$ (NaC*l*) = +5 - 298(43.2/1000) = -7.87 kJ mol^{-1} <0
Reaction is spontaneous, NaC*l* is soluble in water

$\Delta G_{soln}^{\ominus}$ (AgC*l*) = +65.7-298(34.3/1000) = +55.5 kJ mol^{-1}>0
Reaction is not spontaneous, AgC*l* is not soluble in water