

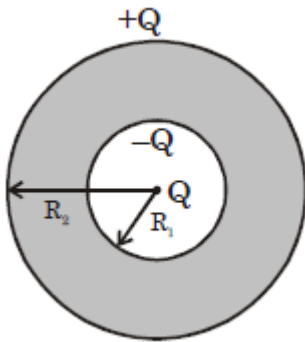
PART (A) : PHYSICS

ANSWER KEY

- | | | | | |
|------------|------------|-----------|-----------|-----------|
| 1. (B) | 2. (A) | 3. (D) | 4. (B) | 5. (1.73) |
| 6. (3) | 7. (30) | 8. (1.5) | 9. (8) | 10. (2) |
| 11. (ABCD) | 12. (ABCD) | 13. (AC) | 14. (AC) | 15. (BD) |
| 16. (C) | 17. (10) | 18. (110) | 19. (320) | |

SOLUTION

1. (B)



(A) $V_D = \frac{kQ}{R_2}$

(B) $V_B = \frac{kQ}{r_1} + \frac{kQ}{R_2} - \frac{kQ}{R_1}$

(C) As potential at D doesnot depends on positon of charge within cavity

(D) Shifting of charge within the cavity will change electric field distribution inside cavity.
So potential at B will change.

2. (A)

For all positions of real object in case of diverging lens. Image will be virtual & diminished on the same side of lens.

3. (D)

4. (B)

$$\begin{aligned} \text{Percentage error in } h &= \frac{dh}{h} \times 100 \\ &= \frac{0.3}{46.2} \times 100 = 0.6\% \end{aligned}$$

$$\text{Percentage error in } t = \frac{0.1}{1.6} \times 100 = 6.25\%$$

Percentage error in $g = (\% \text{ error in } h) + 2 \times (\% \text{ error in } t)$

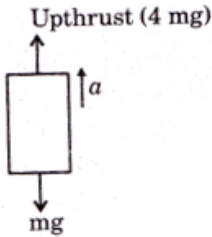
$$\frac{dg}{g} = 13.1\%$$

$$g = 36 \pm 5 \text{ ft/s}^2$$

5. (1.73)

6. (3)

7. (30)



8. (1.5)

The density of liquid is four times that of cylinder, hence in equilibrium position one-fourth of the cylinder is submerged. So as the cylinder is released from initial position, it moves by $\frac{3l}{4}$ to reach its equilibrium position. The upward motion in this time is SHM. Therefore required velocity is

$$v_{\max} = \omega A. \quad \omega = \sqrt{\frac{4g}{l}} \quad \text{and} \quad A = \frac{3l}{4}. \quad \text{Therefore} \quad v_{\max} = \frac{3}{2} \sqrt{gl}$$

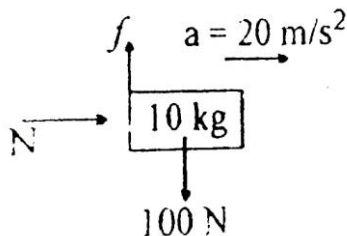
9. (8)

$$\begin{aligned} W_{OAC} &= W_{OA} + W_{AC} = 0 + \int_0^4 x^2 y \, dx \\ &= 0 + \int_0^4 y \, dy = 8 \text{ J} \end{aligned}$$

10. (2)

$$\begin{aligned} W_{OBC} &= W_{OB} + W_{BC} \\ &= 0 + \int_0^1 xy \, dx \\ &= 0 + 4 \int_0^1 x \, dx \\ &= 2 \text{ J} \end{aligned}$$

11. (A, B, C, D)



$$N = 10a = 200 \text{ N}$$

$$f_{\max} = 0.6 \times 200 = 120 \text{ N}$$

$$mg = 100 \text{ N} < f_{\max}$$

∴ The friction is static and $f = 100 \text{ N}$

$$\text{The contact force} = \sqrt{N^2 + f^2} = 100\sqrt{5} \text{ N}$$

12. (A, B, C, D)

$$\text{Orbital speed } (v_0) = \sqrt{\frac{GM}{R}}$$

$$\text{Escapes speed } (v_e) = \sqrt{\frac{2GM}{R}}$$

13. (AC)

Detector will detect maximum light when the image of source is formed at the detector. Let this happens after a time t.

$$\text{At this time } u = -(90 - 10t); v = 10t$$

$$\text{From lens formula } \frac{1}{v} - \frac{1}{u} = \frac{1}{f}; \frac{1}{10t} - \frac{1}{-(90 - 20t)} = \frac{1}{20}$$

This gives t = 3sec and t = 6sec

14. (A, C)

$\theta > \theta_s$ for slipping

$$\Rightarrow \tan \theta > \tan \theta_s$$

$$\Rightarrow \tan 37^\circ > \mu_s$$

$$\Rightarrow 0.75 > \mu_s$$

(B) \therefore Bodies will not slip.

\therefore No compression or expansion

(C) Block B slips, block A doesn't

15. (B, D)

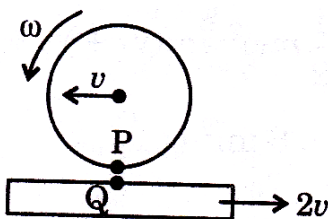
$$y = \sin \omega t + \cos \omega t = \left\{ \sin \omega t \cdot \frac{1}{\sqrt{2}} + \cos \omega t \cdot \frac{1}{\sqrt{2}} \right\} \cdot \sqrt{2}$$

$$= \sqrt{2} \{ \sin \omega t \cos 45^\circ + \cos \omega t \sin 45^\circ \}$$

$$y = \sqrt{2} \sin \left(\omega t + \frac{\pi}{4} \right) \quad \dots\dots(i)$$

Amplitude is $\sqrt{2}$ cm and when t = 0 ,
y = 1 cm [From eq. (i)]

16. (C)



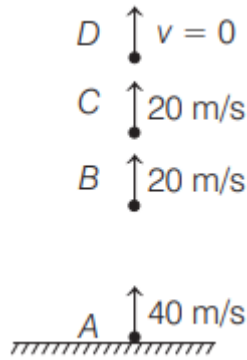
$$-\vec{v}\hat{i} + \omega R\hat{i} = 2v\hat{i}$$

$$\omega = \frac{3v}{R}$$

$$\vec{\omega} = \frac{3v}{R} \hat{k} \quad (\text{For Pure rolling direction must be } \hat{k})$$

17. (10)

18. (110)



From A to B,

$$v^2 = u^2 + 2as$$

$$20^2 = 40^2 + 2(-10)(AB)$$

$$AB = 60\text{m}$$

For next 2s,

$$s = ut + \frac{1}{2}at^2$$

$$BC = 20 \times 2 + \frac{1}{2}(0)(2)^2$$

$$BC = 40\text{m}$$

From C to D,

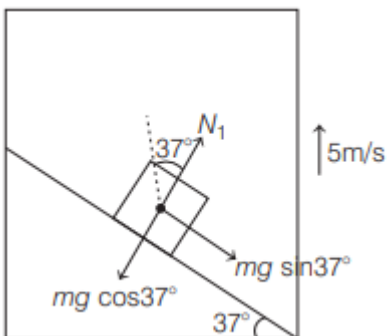
$$v^2 = u^2 + 2as$$

$$0^2 = 20^2 + 2(-20)(CD)$$

$$CD = 10\text{m}$$

$$AB + BC + CD = 60 + 40 + 10 = 110\text{m}$$

19. (320)



$$\Sigma F_y = 0$$

$$\Rightarrow N_1 - mg \cos 37^\circ = 0$$

$$\Rightarrow N_1 = mg \cos 37^\circ$$

$$W_{N_1} = Fs \cos \theta$$

$$= (mg \cos 37^\circ)(vt) \cos 37^\circ = 320\text{ J}$$

PART (B) : CHEMISTRY

ANSWER KEY

20. (A)	21. (B)	22. (D)	23. (C)	24. (12.64-12.65)
25. (120)	26. (0.61-0.62)	27. (0.53)	28. (5)	29. (3)
30. (ABCD)	31. (ACD)	32. (Bonus)	33. (ABCD)	34. (ABD)
35. (CD)	36. (8)	37. (10)	38. (5)	

SOLUTIONS

20. (A)
 $\Delta_f G^\circ$ ($\text{NH}_4\text{Cl}, s$) at 310 K.

$$= S^\circ_{\text{NH}_4\text{Cl}(s)} - \left[\frac{1}{2} S^\circ_{\text{N}_2} + 2S^\circ_{\text{H}_2} + \frac{1}{2} S^\circ_{\text{Cl}_2} \right]$$

$$= -374 \text{ JK}^{-1} \text{ mol}^{-1}$$

$$\therefore \Delta_r C_p = 0$$

$$\therefore \Delta_f S^\circ_{310} = \Delta_f S^\circ_{300}$$

$$= -374 \text{ JK}^{-1} \text{ mol}^{-1}$$

$$\Delta_f H^\circ_{310} = \Delta_f H^\circ_{300} = -314.5$$

$$\Delta_f G^\circ_{310} = \Delta_f H^\circ - 310\Delta S^\circ$$

$$= -314.5 - \frac{310(-374)}{1000}$$

$$= -198.56 \text{ kJ/mol}$$

21. (B)
 $\text{HA} \rightarrow \text{H}^+ + \text{A}^- ; \Delta_r H = 1.4 \text{ kJ/mol}$

$$\Delta H_{\text{neutralization}} = \Delta H_{\text{ionization}} + \Delta_r H$$

$$(\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O})$$

$$-55.95 = \Delta H_{\text{ionization}} - 57.3$$

$$\Delta H_{\text{ionization}} \text{ for } 1 \text{ M HA} = 1.35 \text{ kJ/mol}$$

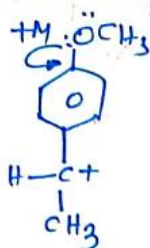
% heat utilized by 1 M acid for ionization

$$= \frac{1.35}{1.4} \times 100 = 96.43\%$$

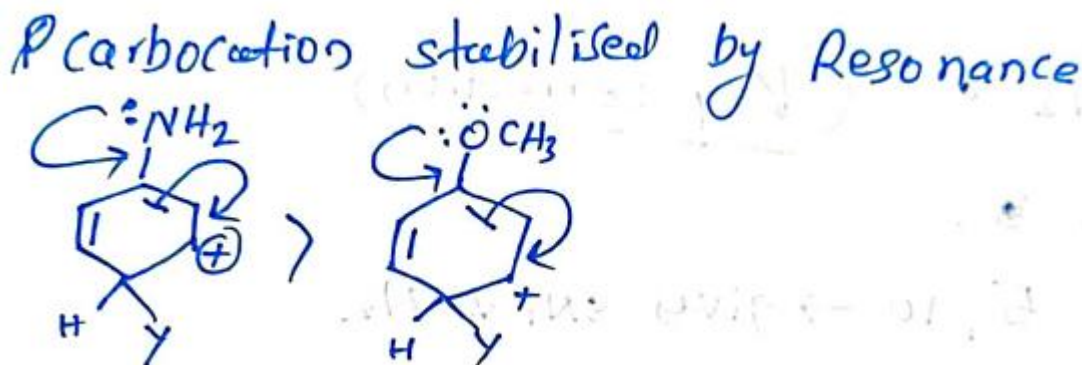
So, acid is $100 - 96.43 = 3.57\%$ ionized

22. (D)

more stable cation lead to maximum racemization



23. (C)

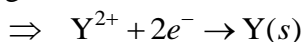


24. (12.65)

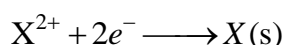
25. (120)

26. (0.62)

When X is connected to SHE, electron flow from X to SHE. This means that X is acting as anode and SHE as cathode and its oxidation potential is positive. Also, the reduction potential of Y is greater than the reduction potential of X (as electrons flow from X to Y).



$$E_{Y^{2+}|Y}^\ominus = 0.34 \text{ V};$$



$$E_{X^{2+}|X}^\ominus = -0.25 \text{ V}$$

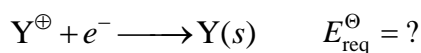
Consider: $X(s) | X^{2+}(0.1 \text{ M}) || Y^{2+}(1.0 \text{ M}) | Y(s)$

$$E_{\text{cell}}^\ominus = E_{\text{cell}}^\ominus - \frac{0.059}{2} \log_{10} \frac{[X^{2+}]}{[Y^{2+}]}$$

$$= [0.34 - (-0.25)] - \frac{0.059}{2} \log_{10} \frac{0.1}{1} = 0.62 \text{ V}$$

27. (0.53)

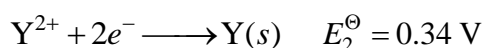
Also,



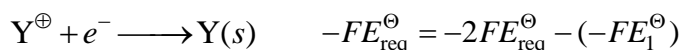
$$\Rightarrow \Delta G_{\text{req}}^\ominus = -1 \times F \times E_{\text{req}}^\ominus$$



$$\Rightarrow \Delta G_1^\ominus = -1 \times F \times E_1^\ominus$$



$$\Rightarrow \Delta G_2^\ominus = -2 \times F \times E_2^\ominus$$



$$\Rightarrow E_{\text{req}}^\ominus = -2E_2^\ominus - E_1^\ominus$$

$$= 2(0.34) - 0.15$$

$$= 0.53 \text{ V}$$

28. (5)
 $SN_2 \rightarrow c, d, e, f, h \text{ (Total=5)}$

29. (3)
 $E_2 \rightarrow b, c, f. \text{ (Total = 3)}$

30. (A, B, C, D)
 At the point of maximum value of RDF

$$\frac{dP}{dr} = 0$$

$$\left(2r - \frac{2Zr^2}{a_0} \right) = 0; \quad r = \frac{a_0}{Z}$$

Where $Z = 3$ for Li^{2+} and $Z = 2$ for the He^+ ; $Z = 1$ for hydrogen.

31. (ACD)

32. (Bonus)

$$\frac{d}{dt} [NH_2CONH_2] = k_4 [NH_3] [HNCO] \text{ from (iii)}$$

Applying steady state approximation to $HNCO$ or NH_3

$$\frac{d[HNCO]}{dt} = 0 = k_3 [NH_4NCO] - k_4 [NH_3] [HNCO]$$

$$\therefore \frac{k_3}{k_4} = \frac{[NH_3] [HNCO]}{[NH_4NCO]}$$

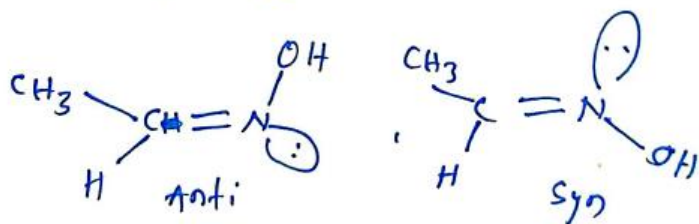
$$\frac{d[\text{urea}]}{dt} = k_4 \times [NH_3] [HNCO] = k_4 \times \frac{k_3}{k_4} [NH_4NCO]$$

$$\text{Also, } [NH_4NCO] = \frac{k_1}{k_2} \times [NH_4CNO]$$

$$\therefore \frac{d[\text{urea}]}{dt} = k_3 \times \frac{k_1}{k_2} \times [NH_4CNO] \\ = k [NH_4CNO]$$

33. (ABCD)

All shows G-I

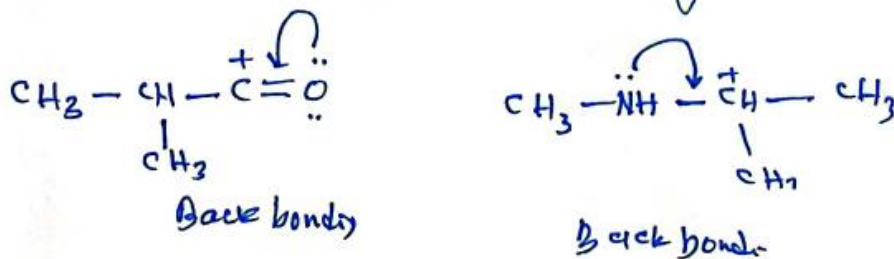


34. (ABD)

conceptual → carbocation stabilised by Resonance

35. (CD)

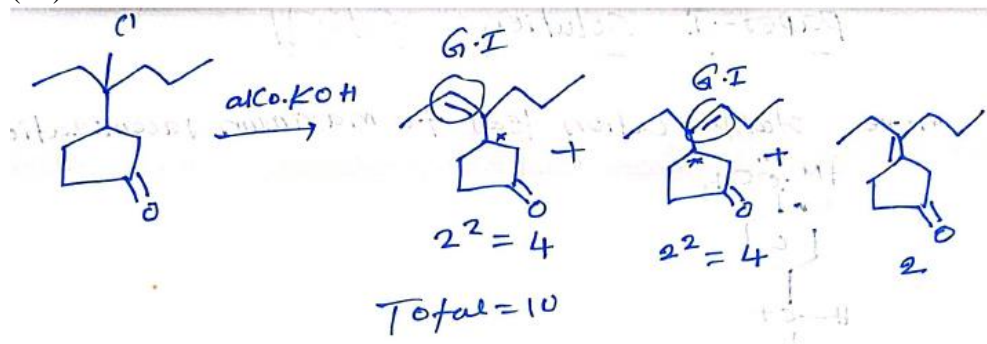
C, O. stabilised by back bonding.



36. (8)

Statements (a), (b) and (c) are correct, so total score = 4 + 1 + 3 = 8.

37. (10)



38. (4)

S_N1 & S_N2

1, 3, 5, 10 → gives S_N1 & S_N2

CH_3-CH_2-Cl does not give S_N1

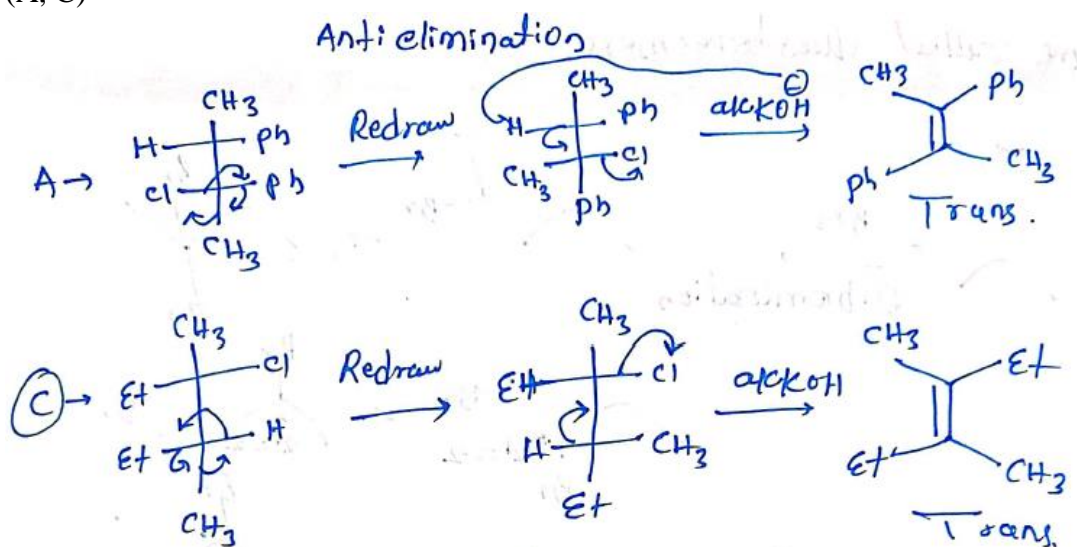
PART (B) : CHEMISTRY

ANSWER KEY

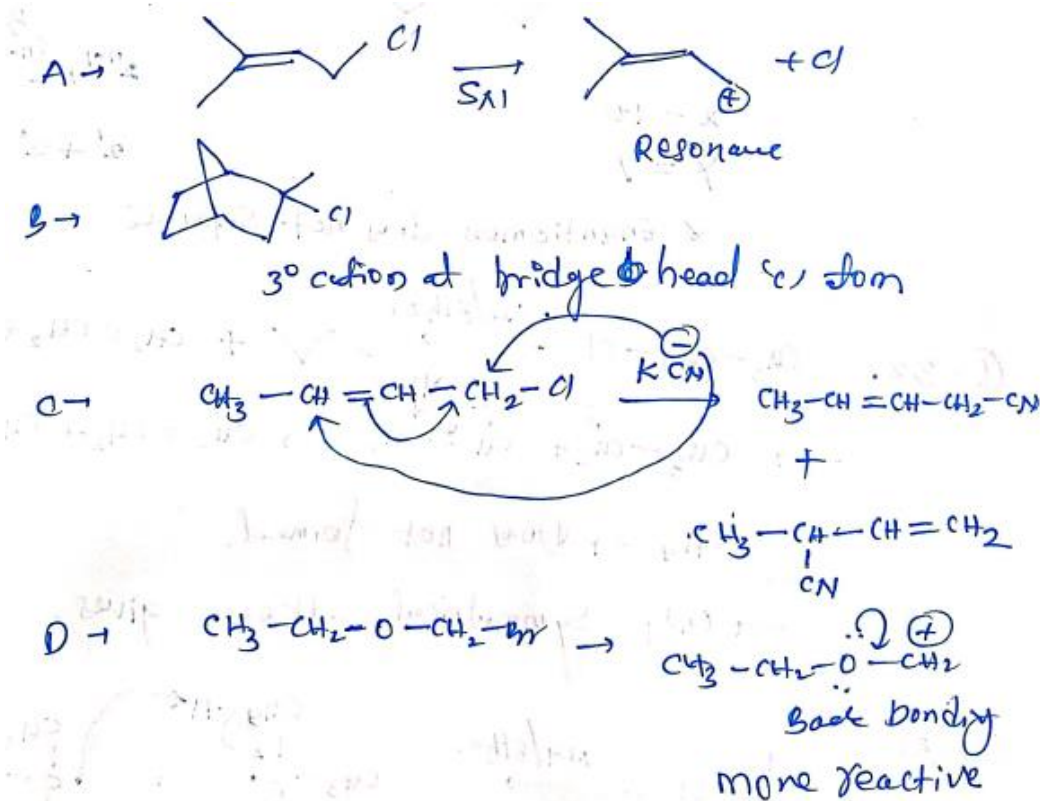
20. (AC)	21. (ABC)	22. (ABCD)	23. (BC)	24. (C, D)
25. (BCD)	26. (190)	27. (1,2)	28. (30.14-30.40)	29. (32.40-32.50)
30. (10)	31. (7)	32. (D)	33. (A)	34. (B)
35. (C)	36. (5)	37. (4)	38. (5)	

SOLUTION

20. (A, C)



21. (ABC)



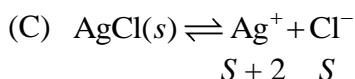
22. (ABCD)

stereomers which are not mirror images of each other are called diastereomers

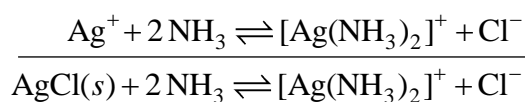
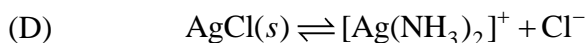
23. (BC)

(A) $S = \sqrt{K_{sp}} = 10^{-5} \text{ mol lit}^{-1}$

(B) $s = 10^{-5} \text{ mol lit}^{-1}$



$$10^{-10} = (S + 2)S \Rightarrow S = \frac{10^{-10}}{2} = 5 \times 10^{-11}$$



$$K = \frac{[\text{Ag}(\text{NH}_3)_2]^+ [\text{Cl}^-]}{[\text{NH}_3]^2} = K_{sp} \times K_f$$

$$\frac{S^2}{(2-S)^2} = 10^{+8} \times 10^{-10} = 10^{-2}$$

$$\frac{S^2}{(2-S)^2} = 10^{-1}$$

$$10S = 2 - S$$

$$S = \frac{2}{11} = 0.182 \text{ M}$$

24. (C, D)

Le Chatelier's principle is not quantitative.

If both stress would cause the same direction of shift, the shift is determinable. If the two stresses would cause shifts in opposite directions, no deduction is possible.

25. (BCD)

26. (190)

$$h_L = \frac{76 \times 13.6}{5.44} = 190 \text{ cm}$$

27. (1.2)

$$P_{\text{gas}} = P_{\text{atm}} + P_L = 1 + \frac{38}{190} = 1.2$$

28. (30.14 – 30.40)

At 2°C (275 K), the reaction is three times slower than at 27°C (300 K).

This implies that for souring of milk.

$$\frac{k_{300}}{k_{275}} = 3, T_1 = 275 \text{ K}, T_2 = 300 \text{ K}$$

Applying Arrhenius equation

$$\log \frac{k_{300}}{k_{275}} = \frac{E_a}{2.303R} \left(\frac{T_2 - T_1}{T_2 T_1} \right)$$

$$\log 3 = \frac{E_a}{2.303 \times 8.314} \left(\frac{300 - 275}{275 \times 300} \right)$$

$$\text{or } E_a = 30.146 \text{ kJ mol}^{-1}$$

29. (32.40 - 32.50)

Now $T_1 = 300 \text{ K}, T_2 = 37^\circ \text{C} = 310 \text{ K}$

$$E_a = 30146 \text{ J mol}^{-1}$$

$$\log \frac{k_{310}}{k_{300}} = \frac{30146 \text{ J mol}^{-1}}{2.303 \times 8.314} \times \frac{310 - 300}{300 \times 310} = 0.1693$$

$$\therefore \frac{k_{310}}{k_{300}} = \text{antilog}(0.1693) = 1.477$$

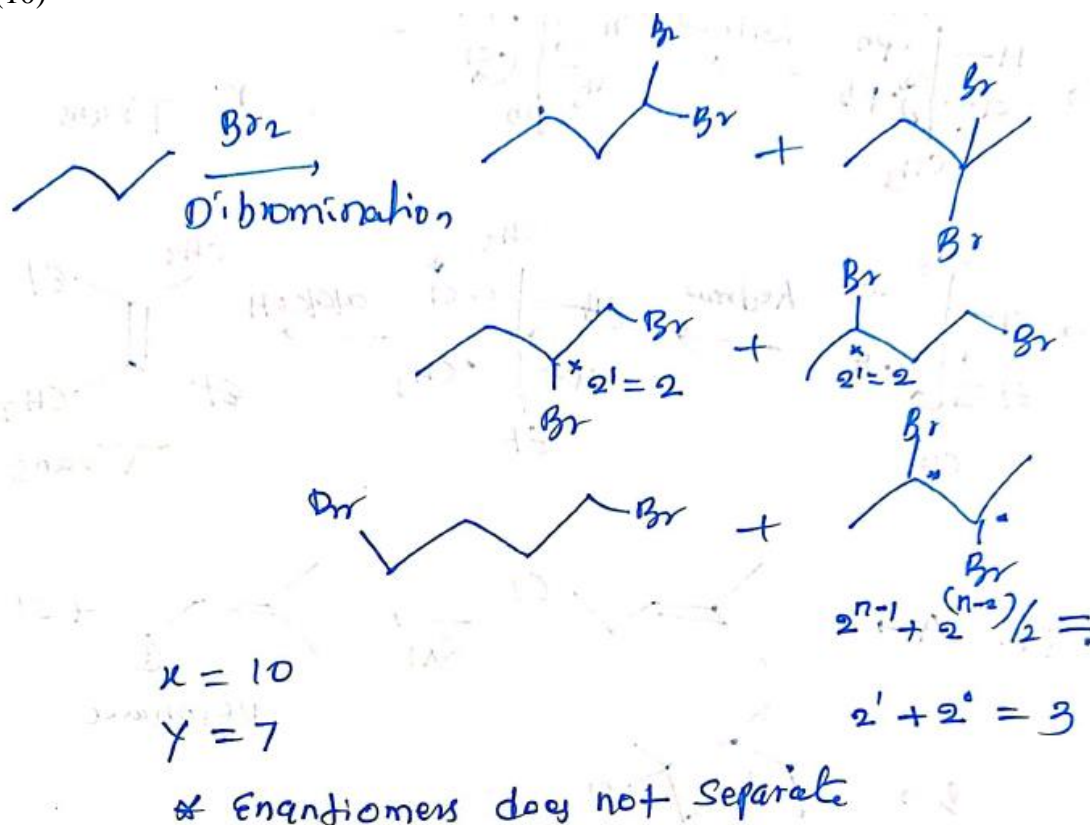
Higher the rate constant, faster is the reaction, i.e., lesser is the time taken, hence

$$\frac{t_{310}}{t_{300}} = \frac{k_{300}}{k_{310}} = \frac{1}{1.477}$$

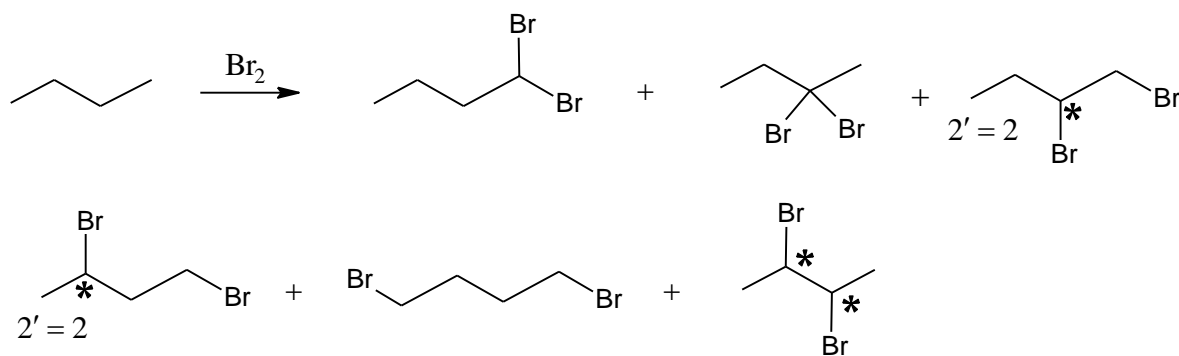
$$\therefore t_{310} = t_{300} \times \frac{1}{1.477} = \frac{48}{1.477} = 32.5 \text{ hr}$$

Solution for Stem Question Nos. 30 and 31

30. (10)



31. (7)

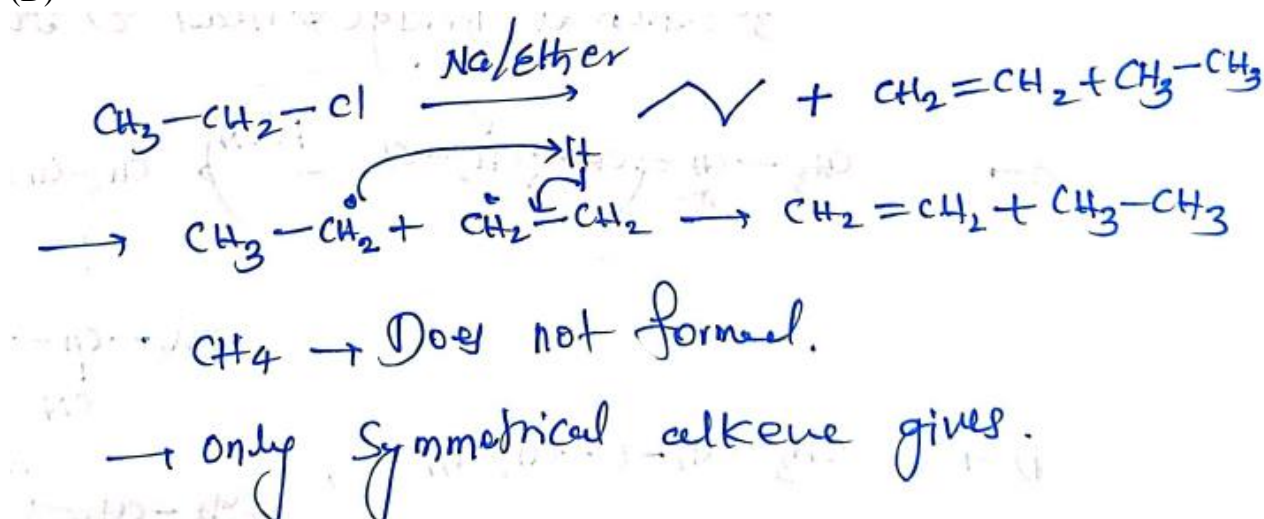


Three stereomers

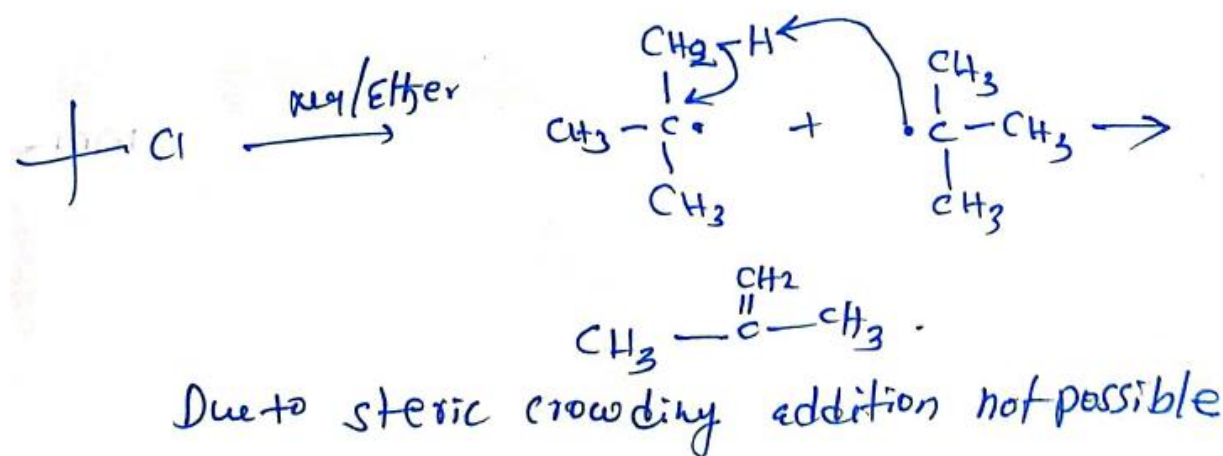
X = 10

Y = 7

32. (D)



33. (A)



34. (B)

$$k_{310} > k_{300} \text{ and } k \propto \frac{1}{E_a} \text{ and also } E_a \propto \frac{1}{T}$$

But E_a at 310K < E_a at 300K

$\therefore \frac{k_{310}}{k_{300}}$ will be maximum for the reaction having high E_a .

35. (C)

For first reaction:

$$\log k_1 = \log A - \frac{E_a}{RT_1}$$

$$\log k_2 = \log A - \frac{E_a}{RT_2}$$

$$\therefore \log \frac{k_2}{k_1} = \frac{E_a}{R} \left(\frac{T_2 - T_1}{T_1 T_2} \right)$$

Similarly, for second reaction,

$$\log \frac{k'_2}{k'_1} = \frac{E'_a}{R} \left(\frac{T_2 - T_1}{T_1 T_2} \right)$$

From Eqs. (i) and (ii),

$$\frac{k_2}{k_1} \propto E_a \text{ and } \frac{k'_2}{k'_1} \propto E'_a$$

Since $E_a > E'_a$

$$\therefore \frac{k_2}{k_1} > \frac{k'_2}{k'_1} \Rightarrow \frac{k'_1}{k_1} > \frac{k'_2}{k_2}$$

36. (5)

For second order reaction:

$$[R]_{\text{initial}} = 0.08 \text{ M}; [R]_{\text{final}} = 0.01 \text{ M}$$

$$x = 0.08 - 0.01 = 0.07 \text{ M}$$

$$\therefore (a - x) = 0.08 - 0.07 = 0.01 \text{ M}$$

$$k_2 = \frac{1}{t} \cdot \frac{x}{a(a-x)}$$

$$= \frac{1}{70 \text{ min}} \times \frac{0.07 \text{ M}}{0.08 \text{ M} \times 0.01 \text{ M}} \quad \dots \text{ (i)}$$

Now, time required to become concentration = 0.04 M.

i.e., $x = 0.04 \text{ M}$

$$k_2 = \frac{1}{t} \times \frac{0.04 \text{ M}}{0.08 \text{ M} \times (0.08 - 0.04) \text{ M}} \quad \dots \text{ (ii)}$$

From Eqs. (i) and (ii)

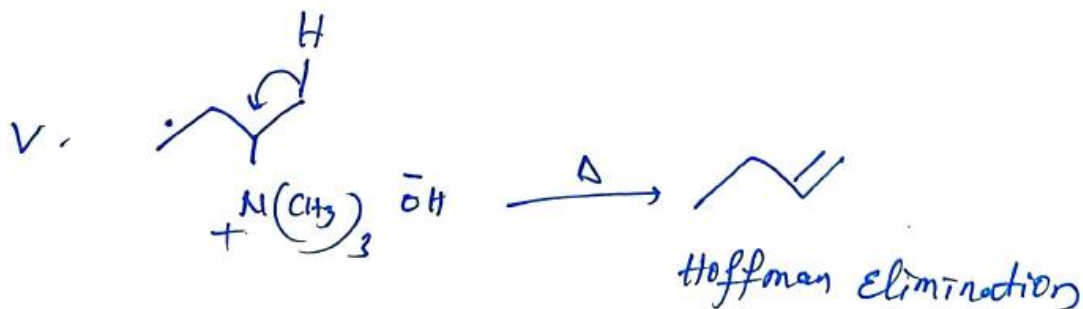
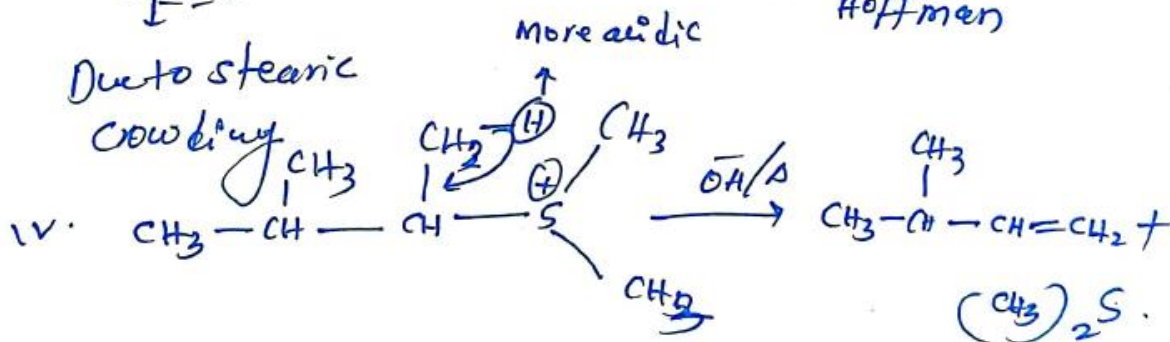
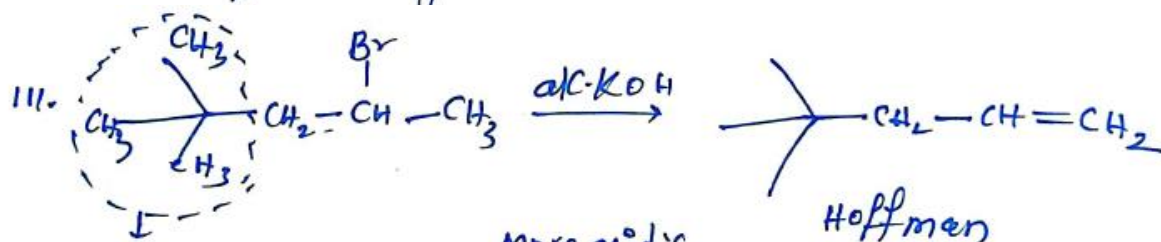
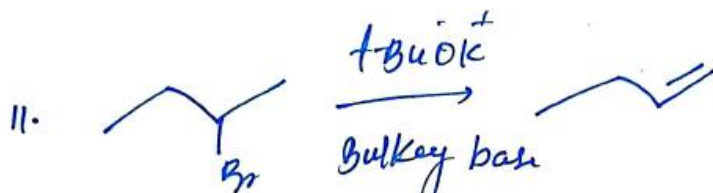
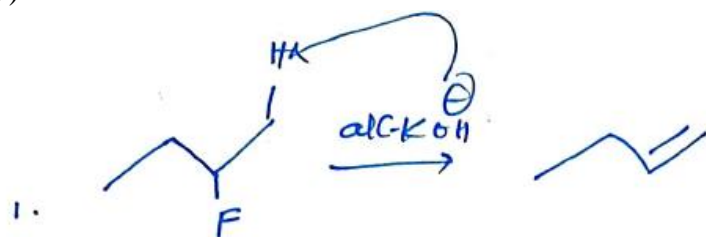
$$\frac{0.07}{70 \times 0.08 \times 0.01} = \frac{0.04}{t \times 0.08 \times 0.04}$$

$$t = 10 \text{ min} = 2x \text{ min}$$

$$\therefore x = 5 \text{ min}$$

37. (4)

38. (5)



Ans = 5 (all reaction gives Hoffmann.)

PART (B) : CHEMISTRY

ANSWER KEY

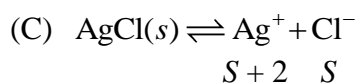
20. (BC)	21. (CD)	22. (BCD)	23. (AC)	24. (ABC)
25. (ABCD)	26. (10)	27. (7)	28. (190)	29. (1.2)
30. (30.14-30.40)	31. (32.40-32.50)	32. (B)	33. (C)	34. (D)
35. (A)	36. (5)	37. (5)	38. (4)	

SOLUTION

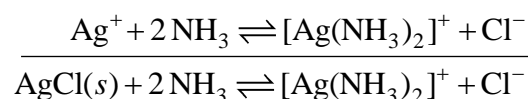
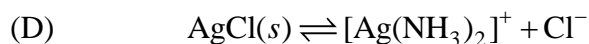
20. (BC)

(A) $S = \sqrt{K_{sp}} = 10^{-5} \text{ mol lit}^{-1}$

(B) $s = 10^{-5} \text{ mol lit}^{-1}$



$$10^{-10} = (S + 2)S \Rightarrow S = \frac{10^{-10}}{2} = 5 \times 10^{-11}$$



$$K = \frac{[\text{Ag}(\text{NH}_3)_2]^+ [\text{Cl}^-]}{[\text{NH}_3]^2} = K_{sp} \times K_f$$

$$\frac{S^2}{(2 - 2S)^2} = 10^{+8} \times 10^{-10} = 10^{-2}$$

$$\frac{S^2}{(2 - 2S)^2} = 10^{-1}$$

$$10S = 2 - 2S$$

$$S = \frac{2}{12} = 0.167 \text{ M}$$

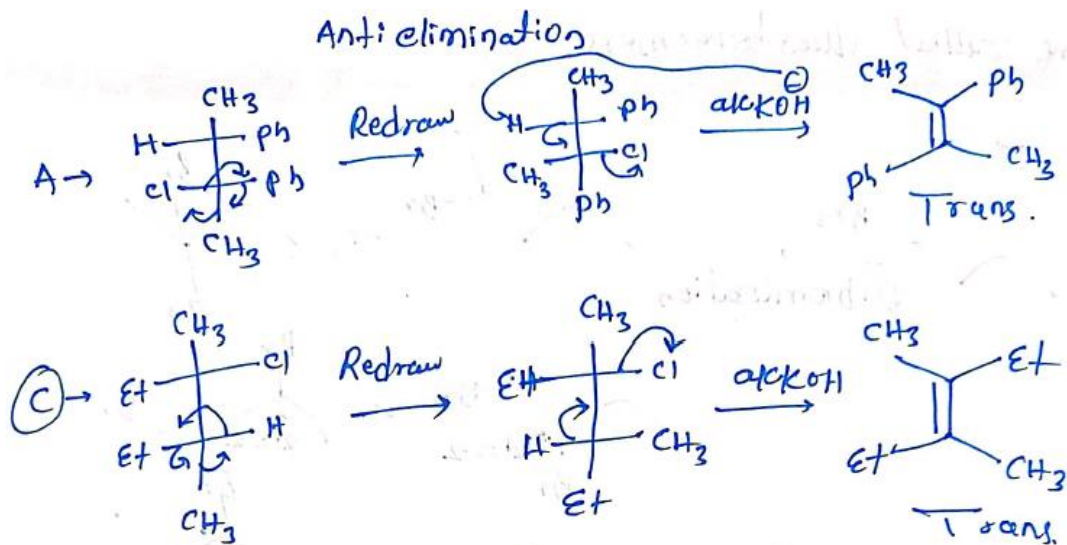
21. (CD)

Le Chatelier's principle is not quantitative.

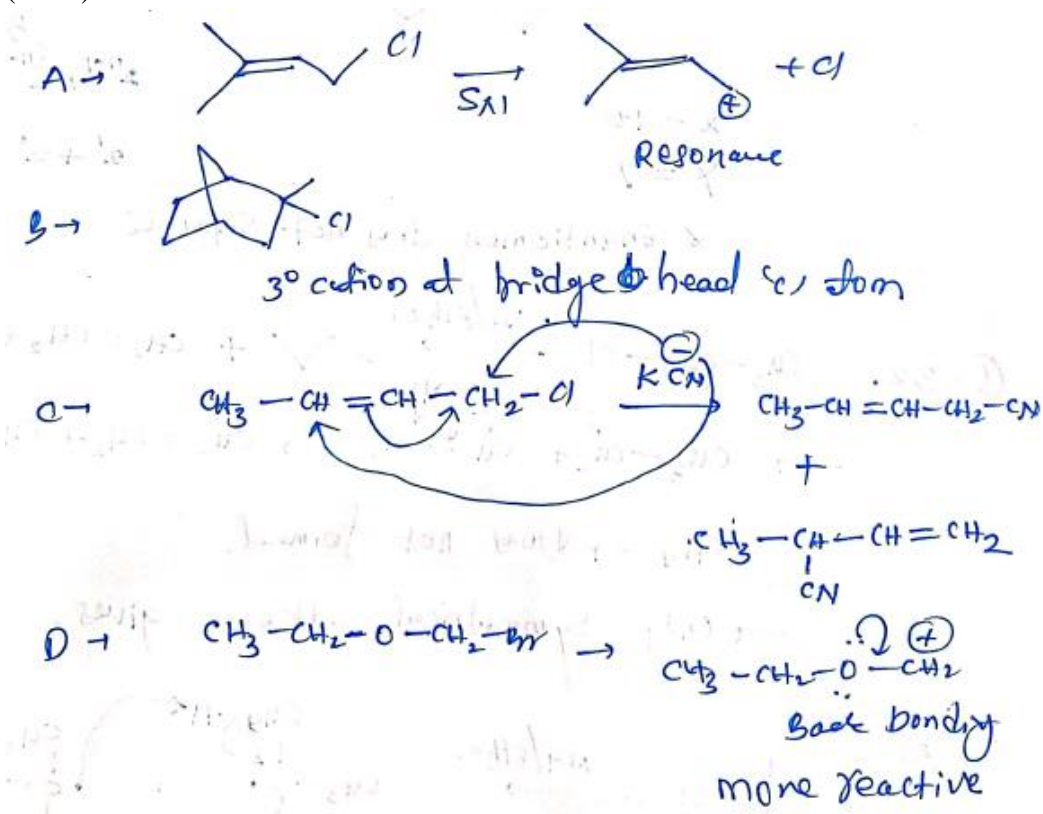
If both stress would cause the same direction of shift, the shift is determinable. If the two stresses would cause shifts in opposite directions, no deduction is possible.

22. (BCD)

23. (AC)



24. (ABC)

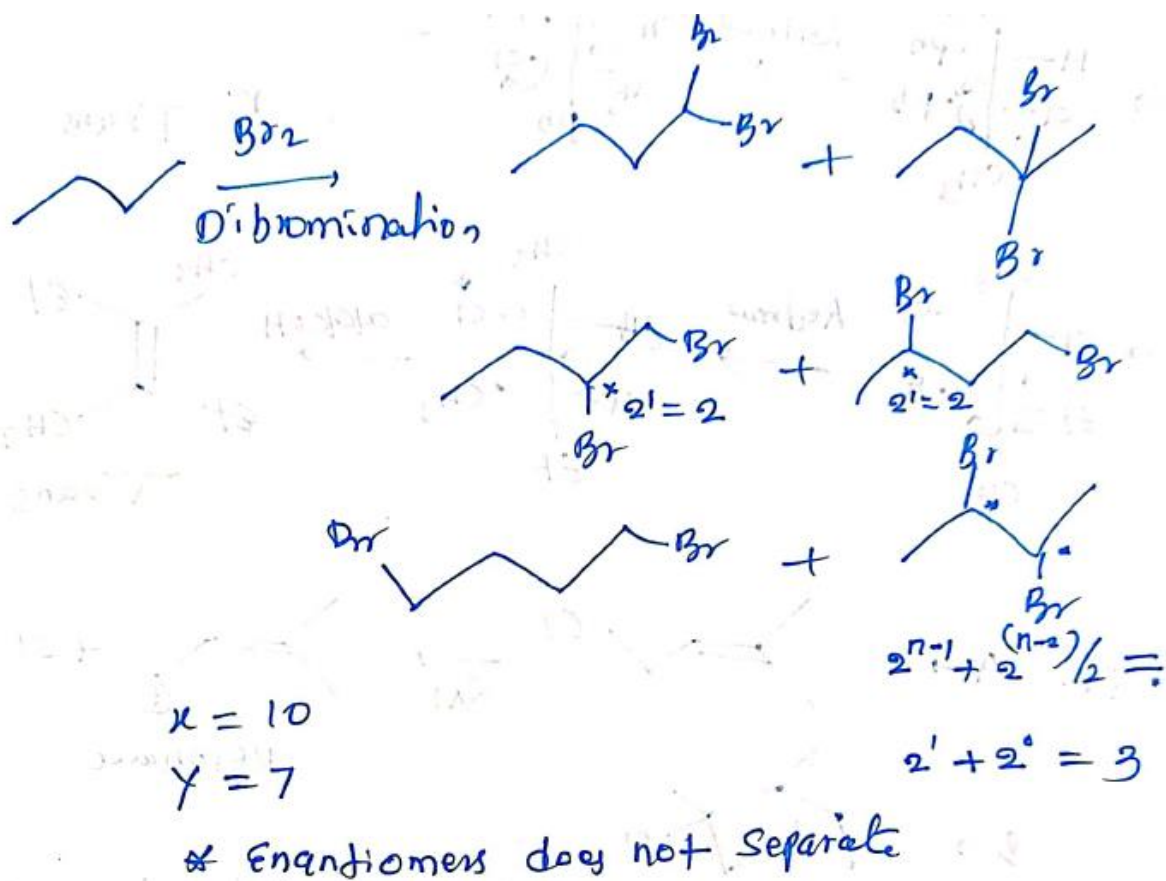


25. (ABCD)

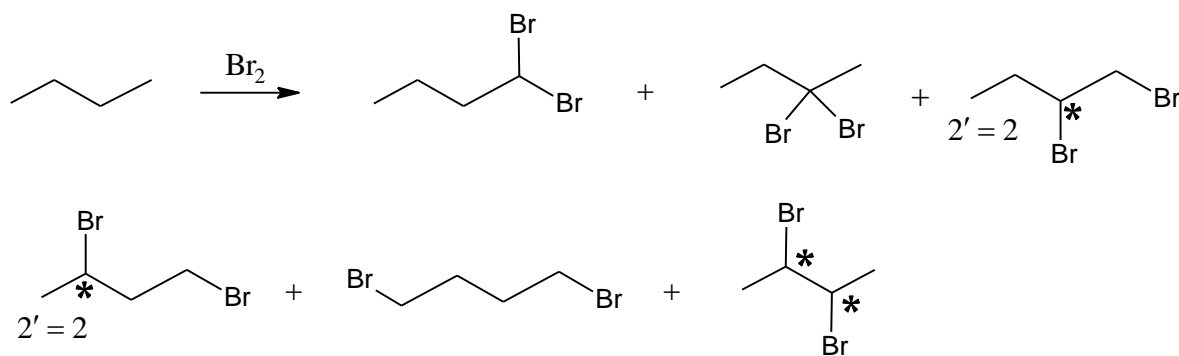
stereomers which are not mirror images of each other are called diastereomers

Solution for Stem Question Nos. 26 and 27

26. (10)



27. (7)



Three stereoisomers

$X = 10$
 $Y = 7$

28. (190)

$$h_L = \frac{76 \times 13.6}{5.44} = 190 \text{ cm}$$

29. (1.2)

$$P_{\text{gas}} = P_{\text{atm}} + P_L = 1 + \frac{38}{190} = 1.2$$

30. (30.14 – 30.40)

At 2°C (275 K), the reaction is three times slower than at 27°C (300 K).

This implies that for souring of milk.

$$\frac{k_{300}}{k_{275}} = 3, T_1 = 275 \text{ K}, T_2 = 300 \text{ K}$$

Applying Arrhenius equation

$$\log \frac{k_{300}}{k_{275}} = \frac{E_a}{2.303R} \left(\frac{T_2 - T_1}{T_2 T_1} \right)$$

$$\log 3 = \frac{E_a}{2.303 \times 8.314} \left(\frac{300 - 275}{275 \times 300} \right)$$

$$\text{or } E_a = 30.146 \text{ kJ mol}^{-1}$$

31. (32.40 – 32.50)

Now $T_1 = 300 \text{ K}, T_2 = 37^\circ \text{C} = 310 \text{ K}$

$$E_a = 30146 \text{ J mol}^{-1}$$

$$\log \frac{k_{310}}{k_{300}} = \frac{30146 \text{ J mol}^{-1}}{2.303 \times 8.314} \times \frac{310 - 300}{300 \times 310} = 0.1693$$

$$\therefore \frac{k_{310}}{k_{300}} = \text{antilog}(0.1693) = 1.477$$

Higher the rate constant, faster is the reaction, i.e., lesser is the time taken, hence

$$\frac{t_{310}}{t_{300}} = \frac{k_{300}}{k_{310}} = \frac{1}{1.477}$$

$$\therefore t_{310} = t_{300} \times \frac{1}{1.477} = \frac{48}{1.477} = 32.5 \text{ hr}$$

32. (B)

$$k_{310} > k_{300} \text{ and } k \propto \frac{1}{E_a} \text{ and also } E_a \propto \frac{1}{T}$$

But E_a at $310\text{K} < E_a$ at 300K

$$\therefore \frac{k_{310}}{k_{300}} \text{ will be maximum for the reaction having high } E_a .$$

33. (C)

For first reaction:

$$\log k_1 = \log A - \frac{E_a}{RT_1}$$

$$\log k_2 = \log A - \frac{E_a}{RT_2}$$

$$\therefore \log \frac{k_2}{k_1} = \frac{E_a}{R} \left(\frac{T_2 - T_1}{T_1 T_2} \right)$$

Similarly, for second reaction,

$$\log \frac{k'_2}{k'_1} = \frac{E'_a}{R} \left(\frac{T_2 - T_1}{T_1 T_2} \right)$$

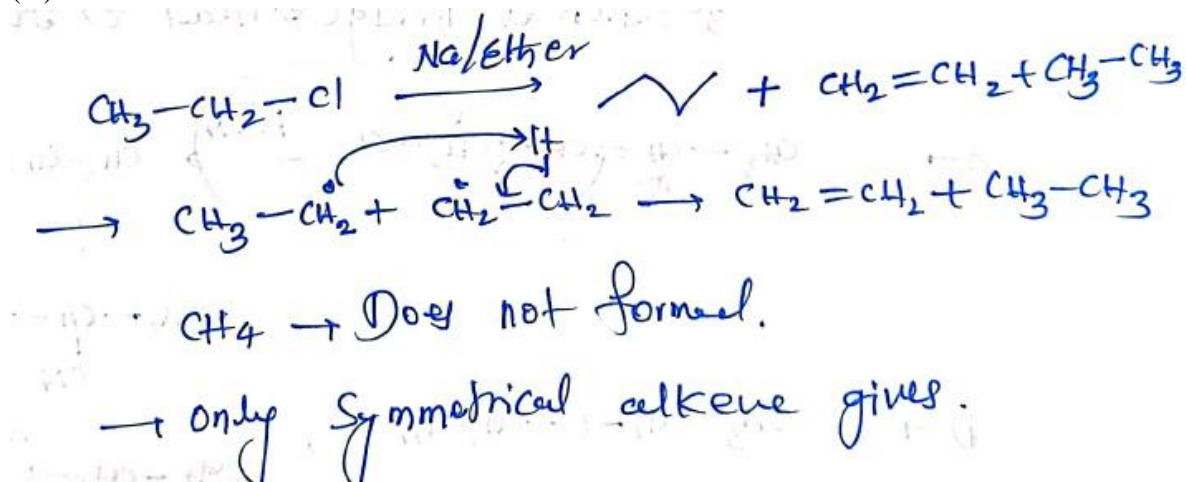
From Eqs. (i) and (ii),

$$\frac{k_2}{k_1} \propto E_a \text{ and } \frac{k'_2}{k'_1} \propto E'_a$$

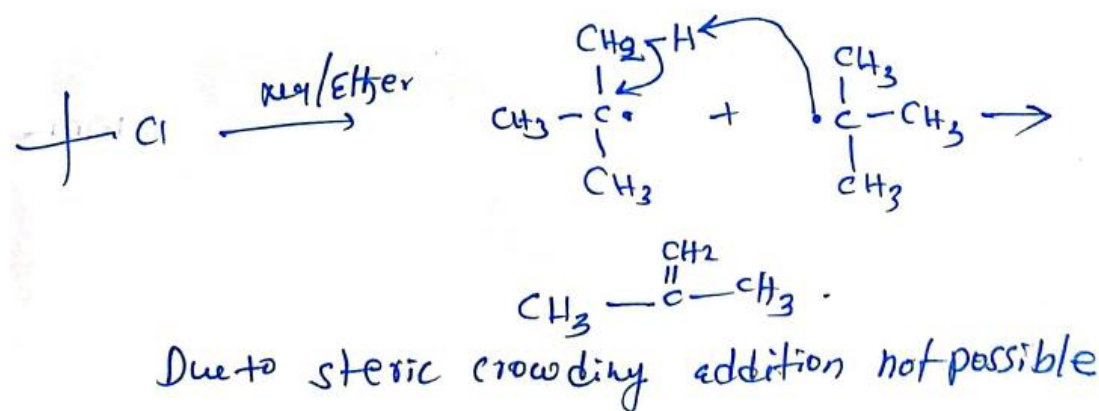
Since $E_a > E'_a$

$$\therefore \frac{k_2}{k_1} > \frac{k'_2}{k'_1} \Rightarrow \frac{k'_1}{k_1} > \frac{k'_2}{k_2}$$

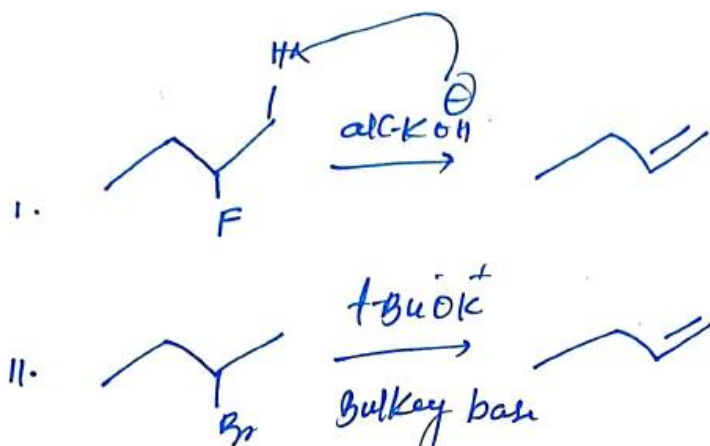
34. (D)

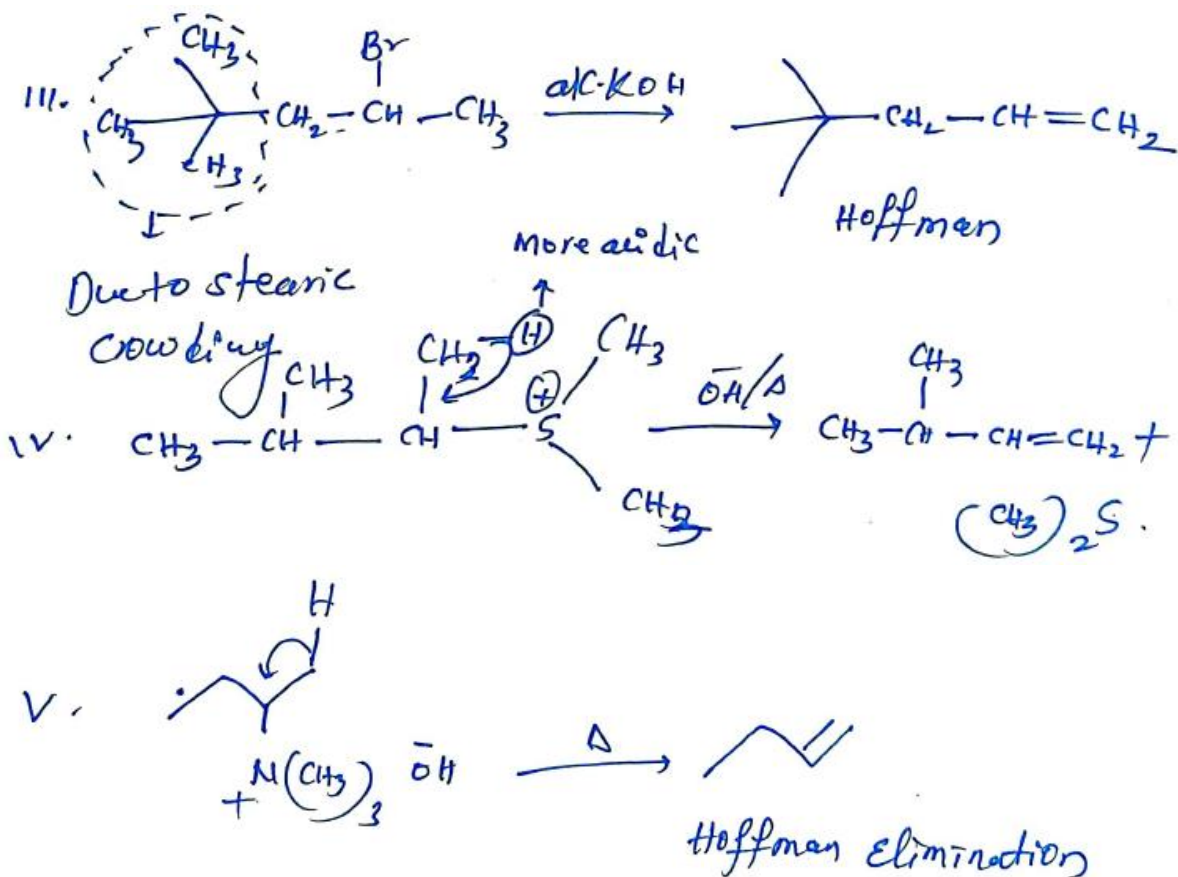


35. (A)



36. (5)





Ans = 5 (all reaction gives Hoffman.)

37. (5)
For second order reaction:
[R]_{initial} = 0.08 M; [R]_{final} = 0.01 M
 $x = 0.08 - 0.01 = 0.07$ M
 $\therefore (a - x) = 0.08 - 0.07 = 0.01$ M

$$k_2 = \frac{1}{t} \cdot \frac{x}{a(a-x)}$$

$$= \frac{1}{70 \text{ min}} \times \frac{0.07 \text{ M}}{0.08 \text{ M} \times 0.01 \text{ M}} \quad \dots \text{ (i)}$$

Now, time required to become concentration = 0.04 M.
i.e., $x = 0.04$ M

$$k_2 = \frac{1}{t} \times \frac{0.04 \text{ M}}{0.08 \text{ M} \times (0.08 - 0.04) \text{ M}} \quad \dots \text{ (ii)}$$

From Eqs. (i) and (ii)

$$\frac{0.07}{70 \times 0.08 \times 0.01} = \frac{0.04}{t \times 0.08 \times 0.04}$$

$$t = 10 \text{ min} = 2x \text{ min}$$

$$\therefore x = 5 \text{ min}$$

38. (4)