

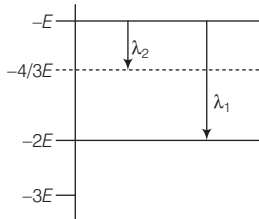
# SOLVED PAPER 2017

## JEE Main

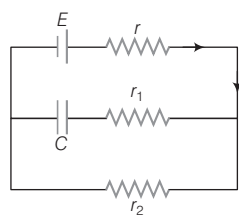
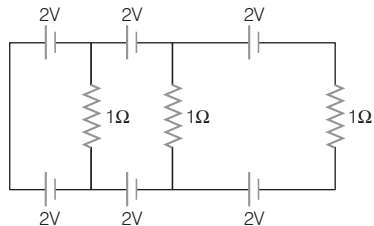
### Instructions

1. This test consists of 90 questions.
2. There are three parts in the question paper consisting of Physics, Chemistry & Mathematics having 30 questions in each part of equal weightage. Each question is allotted 4 marks for correct response.
3. Candidates will be awarded marks as stated above in instruction no. 2 for correct response of each question. 1 mark will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.
4. There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted according as per instructions.

### Physics

1. An observer is moving with half the speed of light towards a stationary microwave source emitting waves at frequency 10 GHz. What is the frequency of the microwave measured by the observer? (speed of light =  $3 \times 10^8 \text{ ms}^{-1}$ )
  - (a) 12.1 GHz
  - (b) 17.3 GHz
  - (c) 15.3 GHz
  - (d) 10.1 GHz
2. The following observations were taken for determining surface tension  $T$  of water by capillary method. Diameter of capillary,  $d = 1.25 \times 10^{-2} \text{ m}$  rise of water,  $h = 1.45 \times 10^{-2} \text{ m}$ . Using  $g = 9.80 \text{ m/s}^2$  and the simplified relation  $T = \frac{r h g}{2} \times 10^3 \text{ N/m}$ , the possible error in surface tension is closest to
  - (a) 1.5%
  - (b) 2.4%
  - (c) 10%
  - (d) 0.15%
3. Some energy levels of a molecule are shown in the figure. The ratio of the wavelengths  $r = \lambda_1 / \lambda_2$  is given by
 
  - (a)  $r = \frac{2}{3}$
  - (b)  $r = \frac{3}{4}$
  - (c)  $r = \frac{1}{3}$
  - (d)  $r = \frac{4}{3}$
4. A body of mass  $m = 10^{-2} \text{ kg}$  is moving in a medium and experiences a frictional force  $F = -kv^2$ . Its initial speed is  $v_0 = 10 \text{ ms}^{-1}$ . If, after 10 s, its energy is  $\frac{1}{8} mv_0^2$ , the value of  $k$  will be
  - (a)  $10^{-3} \text{ kgs}^{-1}$
  - (b)  $10^{-4} \text{ kgm}^{-1}$
  - (c)  $10^{-1} \text{ kgm}^{-1} \text{ s}^{-1}$
  - (d)  $10^{-3} \text{ kgm}^{-1}$

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5.  $C_p$  and  $C_v$  are specific heats at constant pressure and constant volume, respectively. It is observed that  $C_p - C_v = a$  for hydrogen gas  $C_p - C_v = b$  for nitrogen gas. The correct relation between  $a$  and  $b$  is
- (a)  $a = b$  (b)  $a = 14b$   
 (c)  $a = 28b$  (d)  $a = \frac{1}{14}b$
6. The moment of inertia of a uniform cylinder of length  $l$  and radius  $R$  about its perpendicular bisector is  $I$ . What is the ratio  $l/R$  such that the moment of inertia is minimum?
- (a)  $\frac{\sqrt{3}}{2}$  (b) 1 (c)  $\frac{3}{\sqrt{2}}$  (d)  $\sqrt{\frac{3}{2}}$
7. A radioactive nucleus  $A$  with a half-life  $T$ , decays into a nucleus  $B$ . At  $t = 0$ , there is no nucleus  $B$ . After sometime  $t$ , the ratio of the number of  $B$  to that of  $A$  is 0.3. Then,  $t$  is given by
- (a)  $t = T \frac{\log 1.3}{\log_e 2}$  (b)  $t = T \log 1.3$   
 (c)  $t = \frac{T}{\log 1.3}$  (d)  $t = \frac{T \log_e 2}{2 \log 1.3}$
8. Which of the following statements is false?
- (a) In a balanced Wheatstone bridge, if the cell and the galvanometer are exchanged, the null point is disturbed  
 (b) A rheostat can be used as a potential divider  
 (c) Kirchhoff's second law represents energy conservation  
 (d) Wheatstone bridge is the most sensitive when all the four resistances are of the same order of magnitude
9. A capacitance of  $2 \mu\text{F}$  is required in an electrical circuit across a potential difference of  $1\text{kV}$ . A large number of  $1 \mu\text{F}$  capacitors are available which can withstand a potential difference of not more than  $300 \text{ V}$ . The minimum number of capacitors required to achieve this is
- (a) 16 (b) 24 (c) 32 (d) 2
10. In the given circuit diagram, when the current reaches steady state in the circuit, the charge on the capacitor of capacitance  $C$  will be
- 
- (a)  $CE \frac{r_1}{(r_2 + r)}$   
 (b)  $CE \frac{r_2}{(r + r_2)}$   
 (c)  $CE \frac{r_1}{(r_1 + r)}$   
 (d)  $CE$
11. In the below circuit, the current in each resistance is
- 
- (a) 0.25 A (b) 0.5 A (c) 0 A (d) 1 A
12. In amplitude modulation, sinusoidal carrier frequency used is denoted by  $\omega_c$  and the signal frequency is denoted by  $\omega_m$ . The bandwidth ( $\Delta\omega_m$ ) of the signal is such that  $\Delta\omega_m \ll \omega_c$ . Which of the following frequencies is not contained in the modulated wave?
- (a)  $\omega_c$  (b)  $\omega_m + \omega_c$   
 (c)  $\omega_c - \omega_m$  (d)  $\omega_m$
13. In a common emitter amplifier circuit using an  $n-p-n$  transistor, the phase difference between the input and the output voltages will be
- (a)  $90^\circ$  (b)  $135^\circ$   
 (c)  $180^\circ$  (d)  $45^\circ$

14. A copper ball of mass 100 g is at a temperature  $T$ . It is dropped in a copper calorimeter of mass 100 g, filled with 170 g of water at room temperature. Subsequently, the temperature of the system is found to be  $75^\circ\text{C}$ .  $T$  is (Given, room temperature =  $30^\circ\text{C}$ , specific heat of copper =  $0.1 \text{ cal/g}^\circ\text{C}$ )

- (a)  $885^\circ\text{C}$  (b)  $1250^\circ\text{C}$  (c)  $825^\circ\text{C}$  (d)  $800^\circ\text{C}$

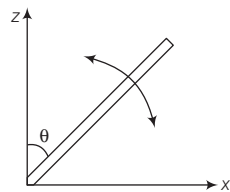
15. In a Young's double slit experiment, slits are separated by 0.5 mm and the screen is placed 150 cm away. A beam of light consisting of two wavelengths, 650 nm and 520 nm, is used to obtain interference fringes on the screen. The least distance from the common central maximum to the point where the bright fringes due to both the wavelengths coincide, is

- (a) 7.8 mm (b) 9.75 mm  
(c) 15.6 mm (d) 1.56 mm

16. An electric dipole has a fixed dipole moment  $\mathbf{p}$ , which makes angle  $\theta$  with respect to  $X$ -axis. When subjected to an electric field  $\mathbf{E}_1 = E_1 \hat{\mathbf{i}}$ , it experiences a torque  $\mathbf{T}_1 = \tau \hat{\mathbf{k}}$ . When subjected to another electric field  $\mathbf{E}_2 = \sqrt{3}E_1 \hat{\mathbf{j}}$ , it experiences a torque  $\mathbf{T}_2 = -\mathbf{T}_1$ . The angle  $\theta$  is

- (a)  $45^\circ$  (b)  $60^\circ$  (c)  $90^\circ$  (d)  $30^\circ$

17. A slender uniform rod of mass  $M$  and length  $l$  is pivoted at one end so that it can rotate in a vertical plane (see the figure). There is negligible friction at the pivot. The free end is held vertically above the pivot and then released. The angular acceleration of the rod when it makes an angle  $\theta$  with the vertical, is



- (a)  $\frac{2g}{3l} \sin \theta$  (b)  $\frac{3g}{2l} \cos \theta$   
(c)  $\frac{2g}{3l} \cos \theta$  (d)  $\frac{3g}{2l} \sin \theta$

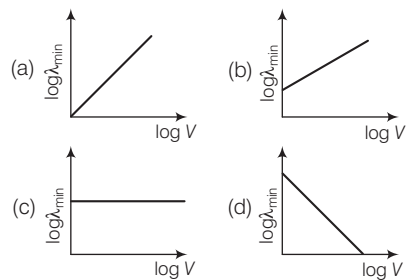
18. An external pressure  $P$  is applied on a cube at  $0^\circ\text{C}$  so that it is equally compressed from all sides.  $K$  is the bulk modulus of the material of the cube and  $\alpha$  is its coefficient of linear expansion. Suppose we want to bring the cube to its original size by heating. The temperature should be raised by

- (a)  $\frac{P}{\alpha K}$  (b)  $\frac{3\alpha}{PK}$  (c)  $3PK\alpha$  (d)  $\frac{P}{3\alpha K}$

19. A diverging lens with magnitude of focal length 25 cm is placed at a distance of 15 cm from a converging lens of magnitude of focal length 20 cm. A beam of parallel light falls on the diverging lens. The final image formed is

- (a) virtual and at a distance of 40 cm from convergent lens  
(b) real and at a distance of 40 cm from the divergent lens  
(c) real and at a distance of 6 cm from the convergent lens  
(d) real and at a distance of 40 cm from convergent lens

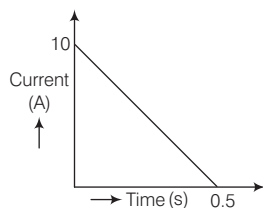
20. An electron beam is accelerated by a potential difference  $V$  to hit a metallic target to produce X-rays. It produces continuous as well as characteristic X-rays. If  $\lambda_{\min}$  is the smallest possible wavelength of X-rays in the spectrum, the variation of  $\log \lambda_{\min}$  with  $\log V$  is correctly represented in



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21. The temperature of an open room of volume  $30 \text{ m}^3$  increases from  $17^\circ\text{C}$  to  $27^\circ\text{C}$  due to the sunshine. The atmospheric pressure in the room remains  $1 \times 10^5 \text{ Pa}$ . If  $n_i$  and  $n_f$  are the number of molecules in the room before and after heating, then  $n_f - n_i$  will be
- $1.38 \times 10^{23}$
  - $2.5 \times 10^{25}$
  - $-2.5 \times 10^{25}$
  - $-1.61 \times 10^{23}$

22. In a coil of resistance  $100 \Omega$ , a current is induced by changing the magnetic flux through it as shown in the figure. The magnitude of change in flux through the coil is

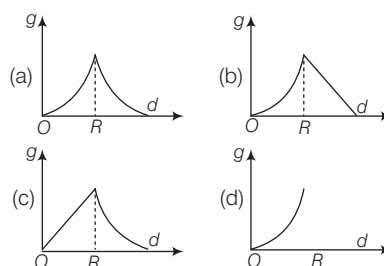


- 225 Wb
  - 250 Wb
  - 275 Wb
  - 200 Wb
23. When a current of  $5 \text{ mA}$  is passed through a galvanometer having a coil of resistance  $15 \Omega$ , it shows full scale deflection. The value of the resistance to be put in series with the galvanometer to convert it into a voltmeter of range  $0\text{-}10 \text{ V}$  is
- $2.045 \times 10^3 \Omega$
  - $2.535 \times 10^3 \Omega$
  - $4.005 \times 10^3 \Omega$
  - $1.985 \times 10^3 \Omega$

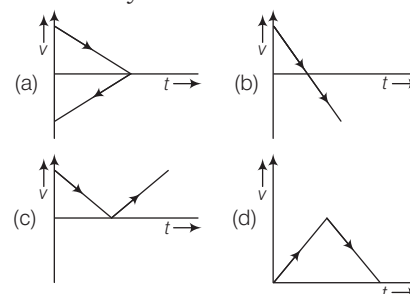
24. A time dependent force  $\mathbf{F} = 6t$  acts on a particle of mass  $1 \text{ kg}$ . If the particle starts from rest, the work done by the force during the first  $1 \text{ s}$  will be
- 22 J
  - 9 J
  - 18 J
  - 4.5 J

25. A magnetic needle of magnetic moment  $6.7 \times 10^{-2} \text{ Am}^2$  and moment of inertia  $7.5 \times 10^{-6} \text{ kg m}^2$  is performing simple harmonic oscillations in a magnetic field of  $0.01 \text{ T}$ . Time taken for 10 complete oscillations is
- 8.89 s
  - 6.98 s
  - 8.76 s
  - 6.65 s

26. The variation of acceleration due to gravity  $g$  with distance  $d$  from centre of the Earth is best represented by ( $R = \text{Earth's radius}$ )

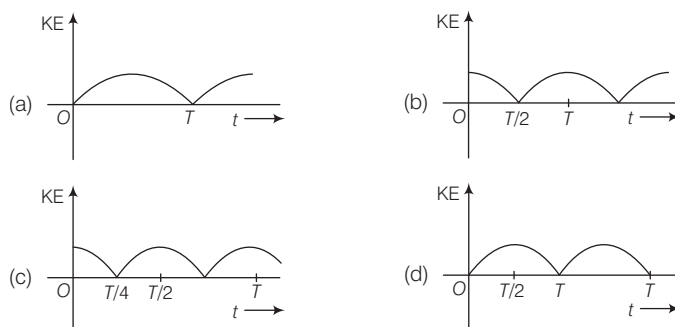


27. A body is thrown vertically upwards. Which one of the following graphs correctly represent the velocity vs time?



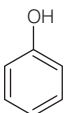
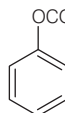
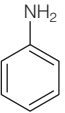
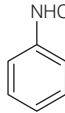
28. A particle **A** of mass  $m$  and initial velocity  $v$  collides with a particle **B** of mass  $\frac{m}{2}$  which is at rest. The collision is head on, and elastic. The ratio of the de-Broglie wavelengths  $\lambda_A$  to  $\lambda_B$  after the collision is
- $\frac{\lambda_A}{\lambda_B} = 2$
  - $\frac{\lambda_A}{\lambda_B} = \frac{2}{3}$
  - $\frac{\lambda_A}{\lambda_B} = \frac{1}{2}$
  - $\frac{\lambda_A}{\lambda_B} = \frac{1}{3}$

29. A particle is executing simple harmonic motion with a time period  $T$ . At time  $t = 0$ , it is at its position of equilibrium. The kinetic energy-time graph of the particle will look, like

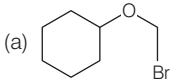
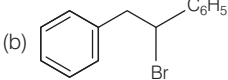
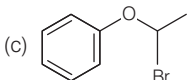
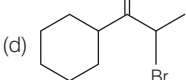
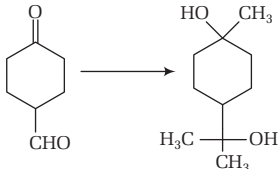


30. A man grows into a giant such that his linear dimensions increase by a factor of 9. Assuming that his density remains same, the stress in the leg will change by a factor of
- (a)  $\frac{1}{9}$                       (b) 81                      (c)  $\frac{1}{81}$                       (d) 9

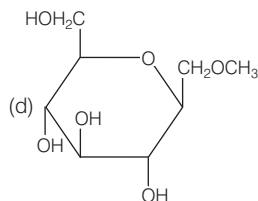
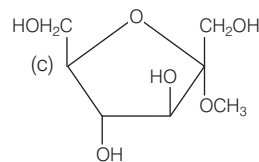
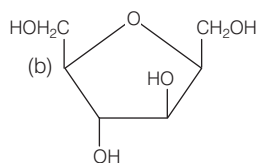
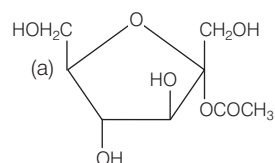
## Chemistry

31. Which of the following compounds will give significant amount of *meta*-product during mononitration reaction?
- (a)                       (b) 
- (c)                       (d) 
32.  $\Delta U$  is equal to
- (a) isochoric work                      (b) isobaric work  
(c) adiabatic work                      (d) isothermal work
33. The increasing order of reactivity of the following halides for the  $S_N1$  reaction is
- I.  $\text{CH}_3\text{CH}(\text{Cl})\text{CH}_2\text{CH}_3$   
II.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$   
III.  $\text{p-H}_3\text{CO}-\text{C}_6\text{H}_4-\text{CH}_2\text{Cl}$
- (a) (III) < (II) < (I)                      (b) (II) < (I) < (III)  
(c) (I) < (III) < (II)                      (d) (II) < (III) < (I)
34. The radius of the second Bohr orbit for hydrogen atom is (Planck's constant ( $h$ ) =  $6.6262 \times 10^{-34}$  Js; mass of electron =  $9.1091 \times 10^{-31}$  kg ; charge of electron ( $e$ ) =  $1.60210 \times 10^{-19}$  C; permittivity of vacuum ( $\epsilon_0$ ) =  $8.854185 \times 10^{-12}$   $\text{kg}^{-1}\text{m}^{-3}\text{A}^2$ )
- (a) 1.65 Å  
(b) 4.76 Å  
(c) 0.529 Å  
(d) 2.12 Å
35.  $\text{pK}_a$  of a weak acid (HA) and  $\text{pK}_b$  of a weak base (BOH) are 3.2 and 3.4, respectively. The pH of their salt (AB) solution is
- (a) 7.2                      (b) 6.9                      (c) 7.0                      (d) 1.0
36. The formation of which of the following polymers involves hydrolysis reaction?
- (a) Nylon-6                      (b) Bakelite  
(c) Nylon-6, 6                      (d) Terylene

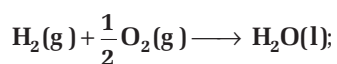
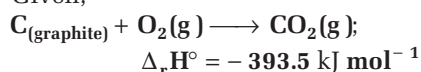
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37. The most abundant elements by mass in the body of a healthy human adult are Oxygen (61.4%); Carbon (22.9%), Hydrogen (10.0 %); and Nitrogen (2.6%). The weight which a 75 kg person would gain if all  $^1\text{H}$  atoms are replaced by  $^2\text{H}$  atoms is  
 (a) 15 kg (b) 37.5 kg (c) 7.5 kg (d) 10 kg
38. Which of the following, upon treatment with *tert*-BuONa followed by addition of bromine water, fails to decolourise the colour of bromine?
- (a)  (b) 
- (c)  (d) 
39. In the following reactions, ZnO is respectively acting as a/an  
 (i)  $\text{ZnO} + \text{Na}_2\text{O} \longrightarrow \text{Na}_2\text{ZnO}_2$   
 (ii)  $\text{ZnO} + \text{CO}_2 \longrightarrow \text{ZnCO}_3$   
 (a) base and acid (b) base and base  
 (c) acid and acid (d) acid and base
40. Both lithium and magnesium display several similar properties due to the diagonal relationship; however, the one which is incorrect is  
 (a) Both form basic carbonates  
 (b) Both form soluble bicarbonates  
 (c) Both form nitrides  
 (d) nitrates of both Li and Mg yield  $\text{NO}_2$  and  $\text{O}_2$  on heating
41. 3-methyl-pent-2-ene on reaction with HBr in presence of peroxide forms an addition product. The number of possible stereoisomers for the product is  
 (a) six (b) zero (c) two (d) four
42. A metal crystallises in a face centred cubic structure. If the edge length of its unit cell is ' $a$ ', the closest approach between two atoms in metallic crystal will be  
 (a)  $2a$  (b)  $2\sqrt{2}a$  (c)  $\sqrt{2}a$  (d)  $\frac{a}{\sqrt{2}}$
43. Two reactions  $\text{R}_1$  and  $\text{R}_2$  have identical pre-exponential factors. Activation energy of  $\text{R}_1$  exceeds that of  $\text{R}_2$  by  $10 \text{ kJ mol}^{-1}$ . If  $k_1$  and  $k_2$  are rate constants for reactions  $\text{R}_1$  and  $\text{R}_2$ , respectively at 300 K, then  $\ln\left(\frac{k_2}{k_1}\right)$  is equal to  
 ( $R = 8.314 \text{ J mol}^{-1}\text{K}^{-1}$ )  
 (a) 8 (b) 12 (c) 6 (d) 4
44. The correct sequence of reagents for the following conversion will be  
  
 (a)  $[\text{Ag}(\text{NH}_3)_2]^+ \text{OH}^-$ ,  $\text{H}^+$  /  $\text{CH}_3\text{OH}$ ,  $\text{CH}_3\text{MgBr}$   
 (b)  $\text{CH}_3\text{MgBr}$ ,  $\text{H}^+$  /  $\text{CH}_3\text{OH}$ ,  $[\text{Ag}(\text{NH}_3)_2]^+ \text{OH}^-$   
 (c)  $\text{CH}_3\text{MgBr}$ ,  $[\text{Ag}(\text{NH}_3)_2]^+ \text{OH}^-$ ,  $\text{H}^+$  /  $\text{CH}_3\text{OH}$   
 (d)  $[\text{Ag}(\text{NH}_3)_2]^+ \text{OH}^-$ ,  $\text{CH}_3\text{MgBr}$ ,  $\text{H}^+$  /  $\text{CH}_3\text{OH}$
45. The Tyndall effect is observed only when following conditions are satisfied  
 1. The diameter of the dispersed particles is much smaller than the wavelength of the light used.  
 2. The diameter of the dispersed particle is not much smaller than the wavelength of the light used.  
 3. The refractive indices of the dispersed phase and dispersion medium are almost similar in magnitude.  
 4. The refractive indices of the dispersed phase and dispersion medium differ greatly in magnitude.  
 (a) 1 and 4 (b) 2 and 4  
 (c) 1 and 3 (d) 2 and 3

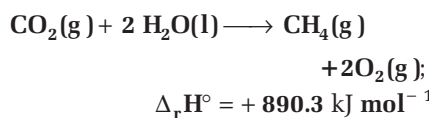
46. Which of the following compounds will behave as a reducing sugar in an aqueous KOH solution?



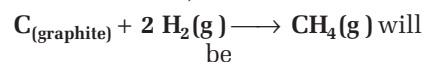
47. Given,



$$\Delta_r H^\circ = -285.8 \text{ kJ mol}^{-1}$$



Based on the above thermochemical equations, the value of  $\Delta_r H^\circ$  at 298 K for the reaction,



- (a) + 78.8 kJ mol<sup>-1</sup> (b) + 144.0 kJ mol<sup>-1</sup>  
 (c) - 74.8 kJ mol<sup>-1</sup> (d) - 144.0 kJ mol<sup>-1</sup>

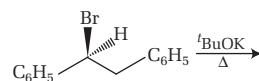
48. Which of the following reactions is an example of a redox reaction?

- (a)  $\text{XeF}_4 + \text{O}_2\text{F}_2 \longrightarrow \text{XeF}_6 + \text{O}_2$   
 (b)  $\text{XeF}_2 + \text{PF}_5 \longrightarrow [\text{XeF}]^+ \text{PF}_6^-$   
 (c)  $\text{XeF}_6 + \text{H}_2\text{O} \longrightarrow \text{XeOF}_4 + 2\text{HF}$   
 (d)  $\text{XeF}_6 + 2\text{H}_2\text{O} \longrightarrow \text{XeO}_2\text{F}_2 + 4\text{HF}$

49. The products obtained when chlorine gas reacts with cold and dilute aqueous NaOH are

- (a)  $\text{ClO}^-$  and  $\text{ClO}_3^-$  (b)  $\text{ClO}_2^-$  and  $\text{ClO}_3^-$   
 (c)  $\text{Cl}^-$  and  $\text{ClO}^-$  (d)  $\text{Cl}^-$  and  $\text{ClO}_2^-$

50. The major product obtained in the following reaction is



- (a)  $(\pm) \text{C}_6\text{H}_5\text{CH}(\text{O}^t\text{Bu})\text{CH}_2\text{C}_6\text{H}_5$   
 (b)  $\text{C}_6\text{H}_5\text{CH} = \text{CHC}_6\text{H}_5$   
 (c)  $(+) \text{C}_6\text{H}_5\text{CH}(\text{O}^t\text{Bu})\text{CH}_2\text{C}_6\text{H}_5$   
 (d)  $(-) \text{C}_6\text{H}_5\text{CH}(\text{O}^t\text{Bu})\text{CH}_2\text{C}_6\text{H}_5$

51. Sodium salt of an organic acid 'X' produces effervescence with conc.  $\text{H}_2\text{SO}_4$ . 'X' reacts with the acidified aqueous  $\text{CaCl}_2$  solution to give a white precipitate which decolourises acidic solution of  $\text{KMnO}_4$ . 'X' is

- (a)  $\text{C}_6\text{H}_5\text{COONa}$  (b)  $\text{HCOONa}$   
 (c)  $\text{CH}_3\text{COONa}$  (d)  $\text{Na}_2\text{C}_2\text{O}_4$


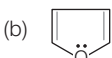

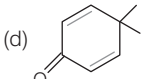
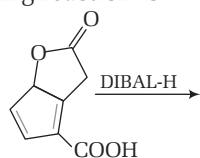
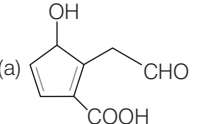
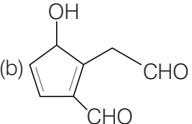
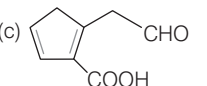
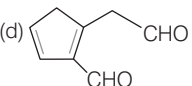
52. Which of the following species is not paramagnetic?

- (a) NO (b) CO  
 (c)  $\text{O}_2$  (d)  $\text{B}_2$

53. The freezing point of benzene decreases by  $0.45^\circ\text{C}$  when 0.2 g of acetic acid is added to 20 g of benzene. If acetic acid associates to form a dimer in benzene, percentage association of acetic acid in benzene will be ( $K_f$  for benzene =  $5.12 \text{ K kg mol}^{-1}$ )

- (a) 64.6% (b) 80.4%  
 (c) 74.6% (d) 94.6%

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54. Which of the following molecules is least resonance stabilised?
- (a)  (b) 
- (c)  (d) 
55. On treatment of 100 mL of 0.1 M solution of  $\text{CoCl}_3 \cdot 6\text{H}_2\text{O}$  with excess of  $\text{AgNO}_3$ ;  $1.2 \times 10^{22}$  ions are precipitated. The complex is
- (a)  $[\text{Co}(\text{H}_2\text{O})_4\text{Cl}_2] \text{Cl} \cdot 2\text{H}_2\text{O}$   
 (b)  $[\text{Co}(\text{H}_2\text{O})_3\text{Cl}_3] \cdot 3\text{H}_2\text{O}$   
 (c)  $[\text{Co}(\text{H}_2\text{O})_6]\text{Cl}_3$   
 (d)  $[\text{Co}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2 \cdot \text{H}_2\text{O}$
56. The major product obtained in the following reaction is
- 
- (a)  (b) 
- (c)  (d) 
57. A water sample has ppm level concentration of following anions  
 $\text{F}^- = 10$ ;  $\text{SO}_4^{2-} = 100$ ;  $\text{NO}_3^- = 50$   
 the anion/anions that make/makes the water sample unsuitable for drinking is/are  
 (a) Only  $\text{NO}_3^-$  (b) Both  $\text{SO}_4^{2-}$  and  $\text{NO}_3^-$   
 (c) Only  $\text{F}^-$  (d) Only  $\text{SO}_4^{2-}$
58. 1 g of a carbonate ( $\text{M}_2\text{CO}_3$ ) on treatment with excess HCl produces 0.01186 mole of  $\text{CO}_2$ . The molar mass of  $\text{M}_2\text{CO}_3$  in  $\text{g mol}^{-1}$  is  
 (a) 1186 (b) 84.3 (c) 118.6 (d) 11.86
59. Given,  $E^\circ_{\text{Cl}_2/\text{Cl}^-} = 1.36 \text{ V}$ ,  
 $E^\circ_{\text{Cr}^{3+}/\text{Cr}} = -0.74 \text{ V}$   
 $E^\circ_{\text{Cr}_2\text{O}_7^{2-}/\text{Cr}^{3+}} = 1.33 \text{ V}$ ,  
 $E^\circ_{\text{MnO}_4^-/\text{Mn}^{2+}} = 1.51 \text{ V}$   
 Among the following, the strongest reducing agent is  
 (a) Cr (b)  $\text{Mn}^{2+}$  (c)  $\text{Cr}^{3+}$  (d)  $\text{Cl}^-$
60. The group having isoelectronic species is  
 (a)  $\text{O}^{2-}$ ,  $\text{F}^-$ ,  $\text{Na}^+$ ,  $\text{Mg}^{2+}$   
 (b)  $\text{O}^-$ ,  $\text{F}^-$ ,  $\text{Na}$ ,  $\text{Mg}^+$   
 (c)  $\text{O}^{2-}$ ,  $\text{F}^-$ ,  $\text{Na}$ ,  $\text{Mg}^{2+}$   
 (d)  $\text{O}^-$ ,  $\text{F}^-$ ,  $\text{Na}^+$ ,  $\text{Mg}^{2+}$

## Mathematics

61. If  $S$  is the set of distinct values of  $b$  for which the following system of linear equations  

$$\begin{aligned} x + y + z &= 1, \Rightarrow x + ay + z = 1 \\ \text{and } ax + by + z &= 0 \end{aligned}$$
 has no solution, then  $S$  is  
 (a) an infinite set  
 (b) a finite set containing two or more elements  
 (c) singleton set  
 (d) an empty set
62. The statement  $(p \rightarrow q) \rightarrow [(\sim p \rightarrow q) \rightarrow q]$  is  
 (a) a tautology  
 (b) equivalent to  $\sim p \rightarrow q$   
 (c) equivalent to  $p \rightarrow \sim q$   
 (d) a fallacy
63. If  $5(\tan^2 x - \cos^2 x) = 2 \cos 2x + 9$ , then the value of  $\cos 4x$  is  
 (a)  $-\frac{3}{5}$  (b)  $\frac{1}{3}$  (c)  $\frac{2}{9}$  (d)  $-\frac{7}{9}$



64. For three events **A**, **B** and **C**,  
 if  $\mathbf{P}$ (exactly one of **A** or **B** occurs)  
 $= \mathbf{P}$ (exactly one of **B** or **C** occurs)  $= \mathbf{P}$   
 (exactly one of **C** or **A** occurs)  $= \frac{1}{4}$   
 and  $\mathbf{P}$  (all the three events occur  
 simultaneously)  $= \frac{1}{16}$ , then the  
 probability that atleast one of the  
 events occurs, is  
 (a)  $\frac{7}{32}$  (b)  $\frac{7}{16}$  (c)  $\frac{7}{64}$  (d)  $\frac{3}{16}$
65. Let  $\omega$  be a complex number such  
 that  $2\omega + 1 = z$ , where  $z = \sqrt{-3}$ . If  

$$\begin{vmatrix} 1 & 1 & 1 \\ 1 & -\omega^2 - 1 & \omega^2 \\ 1 & \omega^2 & \omega^7 \end{vmatrix} = 3k$$
, then  $k$  is  
 equal to  
 (a)  $-z$  (b)  $z$  (c)  $-1$  (d)  $1$
66. Let  $k$  be an integer such that the  
 triangle with vertices  $(k, -3k)$ ,  $(5, k)$   
 and  $(-k, 2)$  has area  
 28 sq units. Then, the orthocentre of  
 this triangle is at the point  
 (a)  $(2, -\frac{1}{2})$  (b)  $(1, \frac{3}{4})$   
 (c)  $(1, -\frac{3}{4})$  (d)  $(2, \frac{1}{2})$
67. If 20 m of wire is available for  
 fencing off a flower-bed in the form  
 of a circular sector, then the  
 maximum area (in sq m) of the  
 flower-bed is  
 (a) 12.5 (b) 10 (c) 25 (d) 30
68. The area (in sq units) of the region  
 $\{(x, y) : x \geq 0, x + y \leq 3, x^2 \leq 4y \text{ and } y \leq 1 + \sqrt{x}\}$  is  
 (a)  $\frac{59}{12}$  (b)  $\frac{3}{2}$  (c)  $\frac{7}{3}$  (d)  $\frac{5}{2}$
69. If the image of the point  $\mathbf{P}(1, -2, 3)$   
 in the plane  $2x + 3y - 4z + 22 = 0$   
 measured parallel to the line  
 $\frac{x}{1} = \frac{y}{4} = \frac{z}{5}$  is  $\mathbf{Q}$ , then  $\mathbf{PQ}$  is equal to  
 (a)  $3\sqrt{5}$  (b)  $2\sqrt{42}$  (c)  $\sqrt{42}$  (d)  $6\sqrt{5}$
70. For  $x \in \left(0, \frac{1}{4}\right)$ , if the derivative of  
 $\tan^{-1}\left(\frac{6x\sqrt{x}}{1-9x^3}\right)$  is  $\sqrt{x} \cdot g(x)$ , then  
 $g(x)$  equals  
 (a)  $\frac{9}{1+9x^3}$  (b)  $\frac{3x\sqrt{x}}{1-9x^3}$   
 (c)  $\frac{3x}{1-9x^3}$  (d)  $\frac{3}{1+9x^3}$
71. If  $(2 + \sin x) \frac{dy}{dx} + (y + 1) \cos x = 0$   
 and  $y(0) = 1$ , then  $y\left(\frac{\pi}{2}\right)$  is equal to  
 (a)  $\frac{1}{3}$  (b)  $-\frac{2}{3}$  (c)  $-\frac{1}{3}$  (d)  $\frac{4}{3}$
72. Let a vertical tower **AB** have its end **A**  
 on the level ground. Let **C** be the  
 mid-point of **AB** and **P** be a point on  
 the ground such that  $\mathbf{AP} = 2\mathbf{AB}$ . If  
 $\angle\mathbf{BPC} = \beta$ , then  $\tan \beta$  is equal to  
 (a)  $\frac{6}{7}$  (b)  $\frac{1}{4}$   
 (c)  $\frac{2}{9}$  (d)  $\frac{4}{9}$
73. If  $\mathbf{A} = \begin{bmatrix} 2 & -3 \\ -4 & 1 \end{bmatrix}$ , then  $\text{adj}$   
 $(3\mathbf{A}^2 + 12\mathbf{A})$  is equal to  
 (a)  $\begin{bmatrix} 72 & -84 \\ -63 & 51 \end{bmatrix}$  (b)  $\begin{bmatrix} 51 & 63 \\ 84 & 72 \end{bmatrix}$   
 (c)  $\begin{bmatrix} 51 & 84 \\ 63 & 72 \end{bmatrix}$  (d)  $\begin{bmatrix} 72 & -63 \\ -84 & 51 \end{bmatrix}$
74. For any three positive real numbers  
 $\mathbf{a}$ ,  $\mathbf{b}$  and  $\mathbf{c}$ , if  
 $9(25\mathbf{a}^2 + \mathbf{b}^2) + 25(\mathbf{c}^2 - 3\mathbf{ac})$   
 $= 15\mathbf{b}(3\mathbf{a} + \mathbf{c})$ , then  
 (a)  $b, c$  and  $a$  are in GP  
 (b)  $b, c$  and  $a$  are in AP  
 (c)  $a, b$  and  $c$  are in AP  
 (d)  $a, b$  and  $c$  are in GP
75. The distance of the point  $(1, 3, -7)$   
 from the plane passing through the

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perpendicular to both the lines

$$\frac{x-1}{1} = \frac{y+2}{-2} = \frac{z-4}{3} \text{ and}$$

$$\frac{x-2}{2} = \frac{y+1}{-1} = \frac{z+7}{-1}, \text{ is}$$

- (a)  $\frac{20}{\sqrt{74}}$  units      (b)  $\frac{10}{\sqrt{83}}$  units  
 (c)  $\frac{5}{\sqrt{83}}$  units      (d)  $\frac{10}{\sqrt{74}}$  units

76. Let  $I_n = \int \tan^n x \, dx$  ( $n > 1$ ). If

$I_4 + I_6 = a \tan^5 x + bx^5 + C$ , where  $C$  is a constant of integration, then the ordered pair  $(a, b)$  is equal to

- (a)  $\left(-\frac{1}{5}, 1\right)$       (b)  $\left(\frac{1}{5}, 0\right)$   
 (c)  $\left(\frac{1}{5}, -1\right)$       (d)  $\left(-\frac{1}{5}, 0\right)$

77. The eccentricity of an ellipse whose centre is at the origin is  $1/2$ . If one of its directrices is  $x = -4$ , then the equation of the normal to it at  $\left(1, \frac{3}{2}\right)$

is

- (a)  $2y - x = 2$       (b)  $4x - 2y = 1$   
 (c)  $4x + 2y = 7$       (d)  $x + 2y = 4$

78. If a hyperbola passes through the point  $P(\sqrt{2}, \sqrt{3})$  and has foci at  $(\pm 2, 0)$ , then the tangent to this hyperbola at  $P$  also passes through the point

- (a)  $(3\sqrt{2}, 2\sqrt{3})$       (b)  $(2\sqrt{2}, 3\sqrt{3})$   
 (c)  $(\sqrt{3}, \sqrt{2})$       (d)  $(-\sqrt{2}, -\sqrt{3})$

79. The function  $f: \mathbf{R} \rightarrow \left[-\frac{1}{2}, \frac{1}{2}\right]$

defined as  $f(x) = \frac{x}{1+x^2}$  is

- (a) invertible  
 (b) injective but not surjective  
 (c) surjective but not injective  
 (d) neither injective nor surjective

80.  $\lim_{x \rightarrow \pi/2} \frac{\cot x - \cos x}{(\pi - 2x)^3}$  equals

- (a)  $\frac{1}{24}$       (b)  $\frac{1}{16}$       (c)  $\frac{1}{8}$       (d)  $\frac{1}{4}$

81. Let  $\mathbf{a} = 2\hat{i} + \hat{j} - 2\hat{k}$ ,  $\mathbf{b} = \hat{i} + \hat{j}$  and  $\mathbf{c}$  be a vector such that  $|\mathbf{c} - \mathbf{a}| = 3$ ,  $|(\mathbf{a} \times \mathbf{b}) \times \mathbf{c}| = 3$  and the angle between  $\mathbf{c}$  and  $\mathbf{a} \times \mathbf{b}$  is  $30^\circ$ . Then,  $\mathbf{a} \cdot \mathbf{c}$  is equal to

- (a)  $\frac{25}{8}$       (b) 2      (c) 5      (d)  $\frac{1}{8}$

82. The normal to the curve  $\mathbf{y}(\mathbf{x} - 2)(\mathbf{x} - 3) = \mathbf{x} + 6$  at the point, where the curve intersects the  $\mathbf{Y}$ -axis passes through the point

- (a)  $\left(-\frac{1}{2}, -\frac{1}{2}\right)$       (b)  $\left(\frac{1}{2}, \frac{1}{2}\right)$   
 (c)  $\left(\frac{1}{2}, -\frac{1}{3}\right)$       (d)  $\left(\frac{1}{2}, \frac{1}{3}\right)$

83. If two different numbers are taken from the set  $\{0, 1, 2, 3, \dots, 10\}$ , then the probability that their sum as well as absolute difference are both multiple of 4, is

- (a)  $\frac{6}{55}$       (b)  $\frac{12}{55}$       (c)  $\frac{14}{45}$       (d)  $\frac{7}{55}$

84. A man  $\mathbf{X}$  has 7 friends, 4 of them are ladies and 3 are men. His wife  $\mathbf{Y}$  also has 7 friends, 3 of them are ladies and 4 are men. Assume  $\mathbf{X}$  and  $\mathbf{Y}$  have no common friends. Then, the total number of ways in which  $\mathbf{X}$  and  $\mathbf{Y}$  together can throw a party inviting 3 ladies and 3 men, so that 3 friends of each of  $\mathbf{X}$  and  $\mathbf{Y}$  are in this party, is

- (a) 485      (b) 468      (c) 469      (d) 484

85. The value of  $({}^{21}C_1 - {}^{10}C_1) + ({}^{21}C_2 - {}^{10}C_2) + ({}^{21}C_3 - {}^{10}C_3) + ({}^{21}C_4 - {}^{10}C_4) + \dots + ({}^{21}C_{10} - {}^{10}C_{10})$  is

- (a)  $2^{21} - 2^{11}$       (b)  $2^{21} - 2^{10}$   
 (c)  $2^{20} - 2^9$       (d)  $2^{20} - 2^{10}$

86. A box contains 15 green and 10 yellow balls. If 10 balls are randomly drawn one-by-one with

the number of green balls drawn is

- (a)  $\frac{12}{5}$  (b) 6 (c) 4 (d)  $\frac{6}{25}$

87. Let  $\mathbf{a}, \mathbf{b}, \mathbf{c} \in \mathbf{R}$ . If  $\mathbf{f}(\mathbf{x}) = \mathbf{ax}^2 + \mathbf{bx} + \mathbf{c}$

be such that  $\mathbf{a} + \mathbf{b} + \mathbf{c} = \mathbf{3}$  and

$\mathbf{f}(\mathbf{x} + \mathbf{y}) = \mathbf{f}(\mathbf{x}) + \mathbf{f}(\mathbf{y}) + \mathbf{xy}$ ,

$\forall \mathbf{x}, \mathbf{y} \in \mathbf{R}$ , then

$\sum_{\mathbf{n}=1}^{10} \mathbf{f}(\mathbf{n})$  is equal to

- (a) 330 (b) 165 (c) 190 (d) 255

88. The radius of a circle having minimum area, which touches the curve  $\mathbf{y} = \mathbf{4} - \mathbf{x}^2$  and the lines  $\mathbf{y} = |\mathbf{x}|$ , is

- (a)  $2(\sqrt{2} + 1)$  (b)  $2(\sqrt{2} - 1)$   
 (c)  $4(\sqrt{2} - 1)$  (d)  $4(\sqrt{2} + 1)$

89. For a positive integer  $\mathbf{n}$ , if the quadratic equation,

$$\mathbf{x}(\mathbf{x} + \mathbf{1}) + (\mathbf{x} + \mathbf{1})(\mathbf{x} + \mathbf{2}) + \dots + (\mathbf{x} + \mathbf{n} - \mathbf{1})(\mathbf{x} + \mathbf{n}) = \mathbf{10n}$$

has two consecutive integral solutions, then  $\mathbf{n}$  is equal to

- (a) 12 (b) 9  
 (c) 10 (d) 11

90.  $\int_{\pi/4}^{3\pi/4} \frac{\mathbf{dx}}{\mathbf{1} + \mathbf{cos} \mathbf{x}}$  is equal to

- (a) -2 (b) 2  
 (c) 4 (d) -1

## Answer with Explanation

### Physics

1. (b) As the observer is moving towards the source, so frequency of waves emitted by the source will be given by the formula

$$f_{\text{observed}} = f_{\text{actual}} \cdot \left( \frac{1 + v/c}{1 - v/c} \right)^{1/2}$$

Here, frequency  $\frac{v}{c} = \frac{1}{2}$

$$\text{So, } f_{\text{observed}} = f_{\text{actual}} \left( \frac{3/2}{1/2} \right)^{1/2}$$

$$\therefore f_{\text{observed}} = 10 \times \sqrt{3} = 17.3 \text{ GHz}$$

2. (a) By ascent formula, we have surface tension,

$$T = \frac{rhg}{2} \times 10^3 \frac{\text{N}}{\text{m}}$$

$$= \frac{dhg}{4} \times 10^3 \frac{\text{N}}{\text{m}} \quad \left( \because r = \frac{d}{2} \right)$$

$$\Rightarrow \frac{\Delta T}{T} = \frac{\Delta d}{d} + \frac{\Delta h}{h} \quad [\text{given, } g \text{ is constant}]$$

$$\text{So, percentage} \\ = \frac{\Delta T}{T} \times 100 = \left( \frac{\Delta d}{d} + \frac{\Delta h}{h} \right) \times 100$$

$$= \left( \frac{0.01 \times 10^{-2}}{1.25 \times 10^{-2}} + \frac{0.01 \times 10^{-2}}{1.45 \times 10^{-2}} \right) \times 100 = 15\%$$

$$\therefore \frac{\Delta T}{T} \times 100 = 15\%$$

3. (c) We have,  $\lambda = \frac{hc}{\Delta E}$

So, ratio of wave lengths

$$\frac{\lambda_1}{\lambda_2} = \frac{hc / \Delta E_1}{hc / \Delta E_2} = \frac{\Delta E_2}{\Delta E_1} = \frac{\left( \frac{4}{3} E - E \right)}{2E - E} = \frac{1}{3}$$

4. (b) Given, force,  $F = -k v^2$

$$\therefore \text{Acceleration, } a = \frac{-k}{m} v^2$$

$$\text{or } \frac{dv}{dt} = \frac{-k}{m} v^2 \Rightarrow \frac{dv}{v^2} = -\frac{k}{m} dt$$

Now, with limits, we have

$$\int_{10}^v \frac{dv}{v^2} = -\frac{k}{m} \int_0^t dt$$

$$\Rightarrow \left( -\frac{1}{v} \right)_{10}^v = -\frac{k}{m} t \Rightarrow \frac{1}{v} = 0.1 + \frac{kt}{m}$$

$$\Rightarrow v = \frac{1}{0.1 + \frac{kt}{m}} = \frac{1}{0.1 + 1000k}$$

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$$\Rightarrow \frac{1}{2} \times m \times v^2 = \frac{1}{8} m v_0^2$$

$$\Rightarrow v = \frac{v_0}{2} = 5$$

$$\Rightarrow \frac{1}{0.1 + 1000 k} = 5 \Rightarrow 1 = 0.5 + 5000 k$$

$$\Rightarrow k = \frac{0.5}{5000} \Rightarrow k = 10^{-4} \text{ kg/m}$$

5. (b) By Mayer's relation, for 1 g mole of a gas,

$$C_p - C_V = R$$

So, when  $n$  gram moles are given,

$$C_p - C_V = \frac{R}{n}$$

As per given question,

$$a = C_p - C_V = \frac{R}{2}; \text{ for } H_2 \quad \dots (i)$$

$$b = C_p - C_V = \frac{R}{28}; \text{ for } N_2 \quad \dots (ii)$$

From Eqs. (i) and (ii), we get

$$a = 14b$$

6. (d) MI of a solid cylinder about its perpendicular bisector of length is

$$I = m \left( \frac{l^2}{12} + \frac{R^2}{4} \right)$$

$$\Rightarrow I = \frac{mR^2}{4} + \frac{ml^2}{12} = \frac{m^2}{4\pi\rho l} + \frac{ml^2}{12}$$

[ $\because \rho\pi R^2 l = m$ ]

For  $I$  to be maximum,

$$\frac{dI}{dl} = -\frac{m^2}{4\pi\rho} \left( \frac{1}{l^2} \right) + \frac{ml}{6} = 0$$

$$\Rightarrow \frac{m^2}{4\pi\rho} = \frac{ml^3}{6}$$

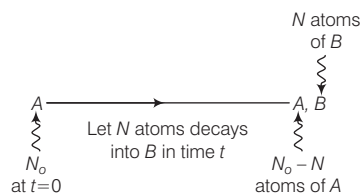
Now, putting  $m = \rho\pi R^2 l$

$$\therefore l^3 = \frac{3}{2\pi\rho} \cdot \rho\pi R^2 l$$

$$\frac{l^2}{R^2} = \frac{3}{2}$$

$$\therefore \frac{l}{R} = \sqrt{\frac{3}{2}}$$

7. (a) Decay scheme is ,



Given,  $\frac{N_B}{N_A} = 0.3 = \frac{3}{10}$

$$\Rightarrow \frac{N_B}{N_A} = \frac{30}{100}$$

So,  $N_0 = 100 + 30 = 130$  atoms

By using  $N = N_0 e^{-\lambda t}$

We have,  $100 = 130 e^{-\lambda t}$

$$\Rightarrow \frac{1}{1.3} = e^{-\lambda t} \Rightarrow \log 1.3 = \lambda t$$

If  $T$  is half-life, then  $\lambda = \frac{\log_e 2}{T}$

$$\Rightarrow \log 1.3 = \frac{\log_e 2}{T} \cdot t$$

$$\therefore t = \frac{T \cdot \log(1.3)}{\log_e 2}$$

8. (a) In a balanced Wheatstone bridge, there is no effect on position of null point, if we exchange the battery and galvanometer. So, option (a) is incorrect.

9. (c) As each capacitors cannot withstand more than 300 V, so there should be four capacitors in each row became in this condition 1 kV i.e. 1000 V will be divided by 4 (i.e. 250 not more than 300 V).

Now, equivalent capacitance of one row

$$= \frac{1}{4} \times 1\mu F = 0.25\mu F$$

[ $\because$  in series combination,  $C_{eq} = \frac{C}{n}$ ]

Now, we need equivalent of  $2\mu F$ , so let we need  $n$  such rows

$$\therefore n \times 0.25 = 2\mu F$$

[ $\because$  in parallel combination  $C_{eq} = nc$ ]

$$n = \frac{2}{0.25}$$

$$= 8$$

$\therefore$  Total number of capacitors  
= number of rows

× number of capacitors in each row  
 =  $8 \times 4 = 32$

10. (b) In steady state, no current flows through the capacitor. So, resistance  $r_p$  becomes ineffective.

So, the current in circuit,

$$I = \frac{E}{r + r_2 \text{ (Total Resistance)}}$$

∴ Potential drop across capacitor

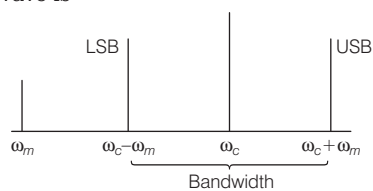
$$= \text{Potential drop across } r_2 = I r_2 = \frac{E r_2}{r + r_2}$$

∴ Stored charge of capacitor,  $Q = CV$

$$= CE \frac{r_2}{r + r_2}$$

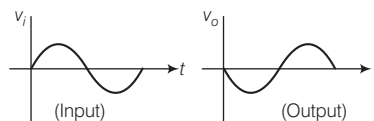
11. (c) Each resistance is converted with two cells combined in opposite direction, so potential drop across each resistor is zero. Hence the current through each of resistor is zero.

12. (d) Frequency spectrum of modulated wave is



Clearly,  $\omega_m$  is not included in the spectrum.

13. (c)



In a CE *n*pn transistor amplifier output is  $180^\circ$  out of phase with input.

14. (a) Heat gained (water + calorimeter)  
 = Heat lost by copper ball  
 $\Rightarrow m_w s_w \Delta T + m_c s_c \Delta T = m_B s_B \Delta T$   
 $\Rightarrow 170 \times 1 \times (75 - 30) + 100 \times 0.1$   
 $\qquad \qquad \qquad \times (75 - 30)$   
 $\qquad \qquad \qquad = 100 \times 0.1 \times (T - 75)$   
 $\therefore T = 885^\circ\text{C}$

15. (a) Let  $n_1$ th fringe formed due to first wavelength and  $n_2$ th fringe formed due to second wavelength coincide i.e. their distance from common central maxima will be same

i.e.  $y_{n_1} = y_{n_2}$   
 $\Rightarrow \frac{n_1 \lambda_1 D}{d} = \frac{n_2 \lambda_2 D}{d}$   
 $\Rightarrow \frac{n_1}{n_2} = \frac{\lambda_1}{\lambda_2} = \frac{520}{650} = \frac{4}{5}$

Hence, distance of the point of coincidence from the central maxima is

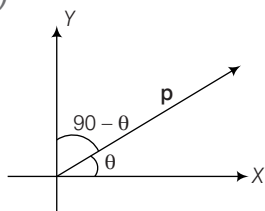
$$y = \frac{n_1 \lambda_1 D}{d}$$

$$= \frac{n_2 \lambda_2 D}{d}$$

$$= \frac{4 \times 650 \times 10^{-9} \times 1.5}{0.5 \times 10^{-3}} = 7.8 \text{ mm}$$

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16. (b)



Torque applied on a dipole  $\tau = pE \sin \theta$  where  $\theta$  = angle between axis of dipole and electric field.

For electric field  $E_1 = E \hat{i}$

it means field is directed along positive X direction, so angle between dipole and field will remain  $\theta$ , therefore torque in this direction

$$E_1 = pE_1 \sin \theta$$

In electric field  $E_2 = \sqrt{3} E \hat{j}$ , it means field is directed along positive Y-axis, so angle between dipole and field will be  $90 - \theta$ .

Torque in this direction

$$T_2 = pE \sin(90 - \theta) \\ = p\sqrt{3} E_1 \cos \theta$$

According to question

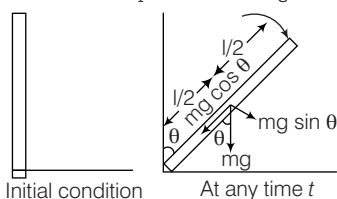
$$\tau_2 = -\tau_1 \Rightarrow |\tau_2| = |\tau_1|$$

$$\therefore pE_1 \sin \theta = p\sqrt{3} E_1 \cos \theta \\ \tan \theta = \sqrt{3}$$

$$\Rightarrow \tan \theta = \tan 60^\circ$$

$$\therefore \theta = 60^\circ$$

17. (d) As the rod rotates in vertical plane so a torque is acting on it, which is due to the vertical component of weight of rod.



Now, Torque  $\tau = \text{force} \times \text{perpendicular distance of line of action of force from axis of rotation}$

$$= mg \sin \theta \times \frac{l}{2}$$

Again, Torque  $\tau = I\alpha$

Where,  $I = \text{moment of inertia} = \frac{ml^2}{3}$

[Force and Torque frequency along axis of rotation passing through in end]

$\alpha = \text{angular acceleration}$

$$\therefore mg \sin \theta \times \frac{l}{2} = \frac{ml^2}{3} \alpha$$

$$\therefore \alpha = \frac{3g \sin \theta}{2l}$$

$$18. (d) K = \frac{P}{(-\Delta V / V)}$$

$$\Rightarrow -\frac{\Delta V}{V} = \frac{P}{K}$$

$$\Rightarrow -\Delta V = \frac{PV}{K}$$

Change in volume  $\Delta V = \gamma v \Delta T$

Where  $r = \text{coefficient of volume expansion}$

Again,  $\gamma = 3\alpha$

$\alpha$  is coefficient of linear expansion

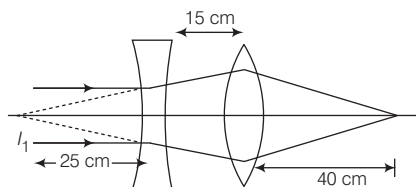
$$\therefore \Delta V = V(3\alpha) \Delta T$$

$$\therefore \frac{PV}{K} = V(3\alpha) \Delta T$$

$$\therefore \Delta T = \frac{P}{3\alpha K}$$

19. (d) Focal length of diverging lens is 25 cm.

As the rays are coming parallel, so the image ( $I_1$ ) will be formed at the focus of diverging lens i.e. at 25 cm towards left of diverging lens.



Now, the image ( $I_1$ ) will work as object for converging lens.

For converging lens, distance of object  $u$

$$\text{(i.e. distance of } I_1) = -(25 + 15) \\ = -40 \text{ cm}$$

$$f = 20 \text{ cm}$$

$$\therefore \text{From len's formula } \frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\frac{1}{20} = \frac{1}{v} - \frac{1}{-40} \Rightarrow \frac{1}{v} = \frac{1}{20} - \frac{1}{40}$$

$$\frac{1}{v} = \frac{1}{90} \Rightarrow v = 40 \text{ cm}$$

$v$  is positive so image will be real and will form at right side of converging lens at 40 cm.

20. (d)  $\lambda_{\min} = \frac{hc}{eV}$   
 $\log(\lambda_{\min}) = \log\left(\frac{hc}{e}\right) - \log V$   
 $y = c - mx$   
 So, the required graph is given in option (d).

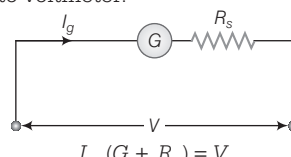
21. (c) From  $pV = nRT = \frac{N}{N_A} RT$   
 We have,  $n_f - n_i = \frac{pV N_A}{RT_f} - \frac{pV N_A}{RT_i}$   
 $\Rightarrow n_f - n_i = \frac{10^5 \times 30}{83} \times 6.02 \times 10^{23}$   
 $\left(\frac{1}{300} - \frac{1}{290}\right)$   
 $= -2.5 \times 10^{25}$   
 $\therefore \Delta n = -2.5 \times 10^{25}$

22. (b) Induced constant,  $I = \frac{e}{R}$   
 Here,  $e =$  induced emf  
 $= \frac{d\phi}{dt}$   
 $I = \frac{e}{R} = \left(\frac{d\phi}{dt}\right) \cdot \frac{1}{R}$   
 $d\phi = IRdt$   
 $\phi = \int IRdt$   
 $\therefore$  Here,  $R$  is constant  
 $\therefore \phi = R \int Idt$   
 $\int I \cdot dt =$  Area under  $I-t$  graph  
 $= \frac{1}{2} \times 10 \times 0.5 = 2.5$   
 $\therefore \phi = R \times 2.5$   
 $= 100 \times 2.5$   
 $= 0.665 \text{ s}$   
 Hence, time for 10 oscillations is  $t = 6.65$  s.

26. (c) Inside the earth surface  $g = \frac{GM}{R^3} r$   
 i.e.  $g \propto r$   
 Out the earth surface  $g = \frac{Gm}{r^2}$   
 i.e.  $g \propto \frac{1}{r^2}$   
 So, till earth surface 'g' increases linearly with distance  $r$ , shown only in graph (c).

$= 250 \text{ Wb.}$

23. (d) Suppose a resistance  $R_s$  is connected in series with galvanometer to convert it into voltmeter.



$I_g (G + R_s) = V$   
 $\Rightarrow R = \frac{V}{I_g} - G$   
 $\Rightarrow R = 1985 = 1.985 \text{ k}\Omega$   
 or  $R = 1.985 \times 10^3 \Omega$

24. (d) From Newton's second law,  $\frac{\Delta p}{\Delta t} = F$

$\Rightarrow \Delta p = F \Delta t$   
 $\therefore p = \int dp = \int_0^1 F dt$   
 $\Rightarrow p = \int_0^1 6t dt = 3 \text{ kg} \left(\frac{\text{m}}{\text{s}}\right)$

Also, change in kinetic energy  
 $\Delta k = \frac{\Delta p^2}{2m} = \frac{3^2}{2 \times 1}$   
 $= 4.5$

From work-energy theorem, work done = change in kinetic energy.  
 So, work done =  $\Delta k = 4.5 \text{ J}$

25. (d) Time period of oscillation is

$T = 2\pi \sqrt{\frac{I}{MB}}$   
 $\Rightarrow T = 2\pi \sqrt{\frac{7.5 \times 10^{-6}}{6.7 \times 10^{-2} \times 0.01}}$

27. (b) Initially velocity keeps on decreasing at a constant rate, then it increases in negative direction with same rate.

28. (a) For elastic collision,

$p_{\text{before collision}} = p_{\text{after collision}}$   
 $mv = mv_A + \frac{m}{2} v_B$   
 $2v = 2v_A + v_B \dots(i)$

Now, coefficient of restitution,

$e = \frac{v_B - v_A}{u_A - v_B}$   
 Here,  $u_B = 0$  (Particle at rest) and for elastic collision  $e = 1$   
 $\therefore 1 = \frac{v_B - v_A}{v} \Rightarrow v = v_B - v_A \dots(ii)$

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From Eq. (i) and Eq. (ii)

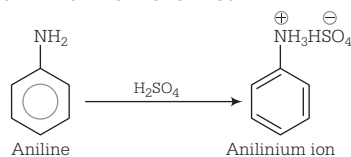
$$v_A = \frac{v}{3} \text{ and } v_B = \frac{4v}{3}$$

$$\text{Hence, } \frac{\lambda_A}{\lambda_B} = \frac{\left(\frac{h}{m v_A}\right)}{\frac{h}{\frac{m}{2} \cdot v_B}} = \frac{V_B}{2V_A} = \frac{4/3}{2/3} = 2$$

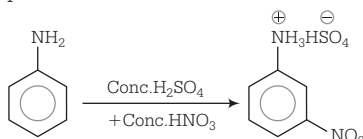
29. (c) KE is maximum at mean position and minimum at extreme position (at  $t = \frac{T}{4}$ ).

## Chemistry

31. (c) Aniline in presence of nitrating mixture (conc.  $\text{HNO}_3$  + conc.  $\text{H}_2\text{SO}_4$ ) gives significance amount ( $\approx 47\%$ ) of meta-product because in presence of  $\text{H}_2\text{SO}_4$  its protonation takes place and anilinium ion is formed.



Here, anilinium ion is strongly deactivating group and *meta*-directing in nature. So, it gives *meta*-nitration product.



32. (c) According to first law of thermodynamics,

$$\Delta U = q + W = q - p\Delta V$$

In isochoric process ( $\Delta V = 0$ ),

$$\Delta U = q$$

In isobaric process ( $\Delta p = 0$ ),

$$\Delta U = q$$

In adiabatic process ( $q = 0$ )

$$\Delta U = W$$

In isothermal process ( $\Delta T = 0$ ) and  $\Delta U = 0$

$\therefore \Delta U$  is equal to adiabatic work.

33. (b) (i) The rate of  $\text{S}_{\text{N}}1$  reaction depends only upon the concentration of the alkyl halide.

30. (d)  $\text{Stress} = \frac{\text{Weight}}{\text{Area}}$

Volume will become  $(9^3)$  times.

So weight = volume  $\times$  density  $\times g$  will also become  $(9^3)$  times.

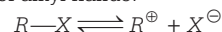
Area of cross section will become  $(9^2)$  times.

$$= \frac{9^3 \times W_0}{9^2 \times A_0} = 9 \left( \frac{W_0}{A_0} \right)$$

Hence, the stress increases by a factor of 9.

(ii)  $\text{S}_{\text{N}}1$  reaction proceeds through the formation of carbocation.

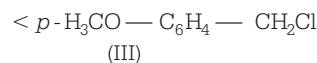
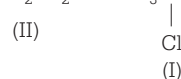
The reactivity is decided by ease of dissociation of alkyl halide.



Higher the stability of  $R^+$  (carbocation), higher would be the reactivity towards  $\text{S}_{\text{N}}1$  reaction.

$p\text{-H}_3\text{CO}-\text{C}_6\text{H}_4-\text{CH}_2^{\oplus}$  is the most stable carbocation due to resonance and then  $\text{CH}_3-\text{C}^{\oplus}\text{H}-\text{CH}_2-\text{CH}_3$  ( $2^{\circ}$  carbocation) while  $\text{CH}_3-\text{CH}_2-\text{C}^{\oplus}\text{H}_2$  ( $1^{\circ}$ ) is least stable.

Thus, the correct increasing order of the reactivity of the given halides towards the  $\text{S}_{\text{N}}1$  reaction is



34. (d) Bohr radius ( $r_n$ ) =  $\epsilon_0 n^2 h^2$

$$r_n = \frac{n^2 h^2}{4\pi^2 m e^2 k Z}$$

$$k = \frac{1}{4\pi \epsilon_0}$$

$$\therefore r_n = \frac{n^2 h^2 \epsilon_0}{\pi m e^2 Z}$$

$$= n^2 \frac{a_0}{Z}$$

where,

$m$  = mass of electron



$e$  = charge of electron  
 $h$  = Planck's constant  
 $k$  = Coulomb constant

$$r_n = \frac{n^2 \times 0.53 \text{ \AA}}{Z}$$

Radius of  $n^{\text{th}}$  Bohr orbit for H-atom  
 $= 0.53 n^2 \text{ \AA}$

[ $Z = 1$  for H-atom]

$\therefore$  Radius of  $2^{\text{nd}}$  Bohr orbit for H-atom  
 $= 0.53 \times (2)^2 = 2.12 \text{ \AA}$

35. (b) For a salt of weak acid and weak base,

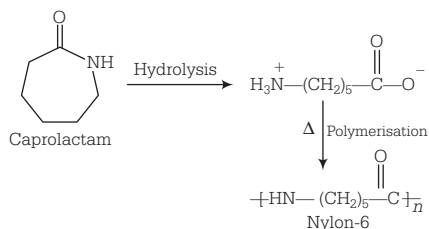
$$\text{pH} = 7 + \frac{1}{2} \text{p}K_a - \frac{1}{2} \text{p}K_b$$

Given,  $\text{p}K_a(\text{HA}) = 3.2$ ,  $\text{p}K_b(\text{BOH}) = 3.4$

$\therefore$   $\text{pH} = 7 + \frac{1}{2}(3.2) - \frac{1}{2}(3.4)$   
 $= 7 + 1.6 - 1.7 = 6.9$

36. (a) Nylon-6 or perlon is prepared by polymerisation of amino caproic acid at high temperature. Caprolactam is first

hydrolysed with water to form amino acid which on heating undergoes polymerisation to give nylon-6.



37. (c) Given, abundance of elements by mass

oxygen = 61.4%, carbon = 22.9%,  
 hydrogen = 10% and nitrogen = 2.6%

Total weight of person = 75 kg

$$\text{Mass due to } ^1\text{H} = \frac{75 \times 10}{100} = 7.5 \text{ kg}$$

$^1\text{H}$  atoms are replaced by  $^2\text{H}$  atoms,

$$\text{Mass due to } ^2\text{H} = (7.5 \times 2) \text{ kg}$$

$\therefore$  Mass gain by person = 7.5 kg