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Session 2024-245

Class: XII **SUBJECT: PHYSICS (THEORY)**

MARKING SCHEME

SECTION A

A1: c **1M**

A2: c $q = \tau/[(2a)\,E\sin\theta] = \dfrac{4}{2\times10^{-2}\times 2\times10^{5}\,\sin 30^\circ}$ **1M**

$= 2\times10^{-3}$ C = 2 mC

A3: b KE = hν - w_0 = 0.51 Ev **1M**

A4: d Here angle of prism A = 60°,

angle of incidence i = angle of emergence e and **1M**

under this condition angle of deviation is minimum

$\therefore i = e = (3/4)\,A = (3/4)\times 60^\circ = 45^\circ$

and $i + e = A + \delta m$,hence $\delta m = 2i - A = 2\times 45^\circ - 60^\circ = 30^\circ$

A5: b **1M**

A6: d **1M**

A7: c **1M**

A8: c **1M**

A9: d **1M**

A10: b **1M**

A11: a **1M**

A12: c **1M**

A13: d **1M**

A14: a **1M**

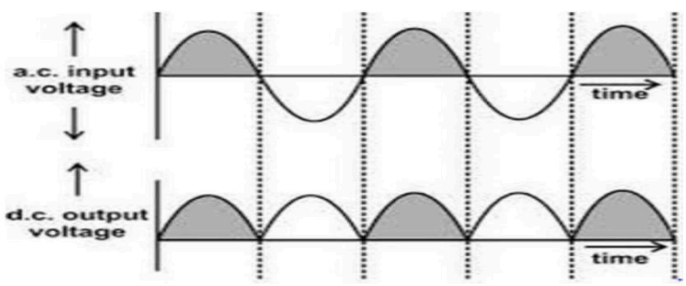
A15: b **1M**

A16: a **1M**

SECTION B

A17: (a) Rectifier **1M**

(b) Input & output waveform of full wave rectifier **1M**



A18: As $^{83}Bi_{209}$ has 83 protons and 126 neutrons (209−83=126)

∴ Mass of $^{83}Bi_{209}$=83×1.007825+126×1.008665 =210.741265 a.m.u. 1/2M

Mass defect of $^{83}Bi_{209}$=210.741265−208.980388 =1.760877 a.m.u. 1/2 M

∴ Binding energy of a $^{83}Bi_{209}$ =1.760877×931 M eV 1/2M

So B.E./nucleons =1.760877×931209 =7.844 M eV/A. 1/2M

A19. In general, any given value of deviation δ, (except for i = e) corresponds to two values i and e. This is expected from the symmetry of i and e as δ= i + e – A, i.e., δ remains the same if i and e are interchanged. 1M

Point P is the point of minimum deviation. This is related to the fact that the path of the ray as shown in Figure can be traced back resulting in the same angle of deviation. At the minimum deviation δm, the refracted ray inside the prism becomes parallel to the base.

1M

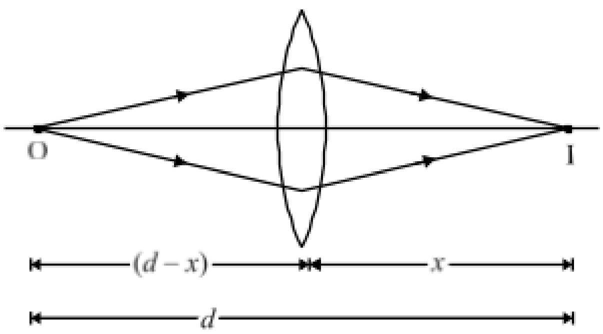
A20. Electric field, $E = V/l$, $v_d = eE\tau/m = eV\tau/ml$

$resistance,\ R = \rho\, l/A = 4\rho l/\pi D^2$

(i) When V doubled, E becomes double, v_d becomes double and R remains unchanged 1M

(ii) When D is doubled, E remains unchanged, v_d is also unchanged and R becomes one – fourth. 1M

A21: Let *d* be the least distance between object and image for a real image formation.



½ M

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$, $\frac{1}{f} = \frac{1}{x} + \frac{1}{d-x} = \frac{d}{x(d-x)}$ ½ M

$fd = xd - x^2$, $x^2 - dx + fd = 0$, $x = \frac{d \pm \sqrt{d^2 - 4fd}}{2}$ ½ M

For real roots of *x*, $d^2 - 4fd \geq 0$ ½ M

$d \geq 4f.$

OR

Let f_o and f_e be the focal length of the objective and eyepiece respectively. For normal adjustment the distance from objective to eyepiece is ($f_o + f_e$).

Taking the line on the objective as object and eyepiece as lens

$u = -(f_o + f_e)$ and $f = f_e$

$\frac{1}{v} - \frac{1}{[-\{fo + fe\}]} = \frac{1}{fe} \Rightarrow v = \left(\frac{f_o + f_e}{f_o}\right) f_e$ 1M

Linear magnification (eyepiece) = $\frac{v}{u} = \frac{Image\ size}{Object\ size} = \frac{f_e}{f_o} = \frac{l}{L}$ – ½ M

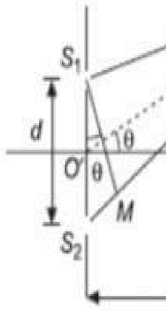
∴ Angular magnification of telescope

$M = \frac{f_0}{f_e} = \frac{L}{l}$ ½ M

SECTION C

Two sources of light which continuously emit light sources of same frequency or (wavelength) with a zero or constant phase difference between them are called coherent sources.
½ M

Two independent monochromatic sources cannot maintain a constant phase difference, therefore, the interference pattern will also change with time.



Consider a point P on the screen. Suppose waves from the slits S_1 and S_2 superpose at the point to produce maximum intensity. Now, path difference between the waves to produce maxima would be

$$\Delta P = n\lambda$$

Here $\Delta P = S_2P - S_1P = S_2M$

From ΔS_2MS_1, $S_2M = S_1 S_2 \sin\theta$

$$S_2M = d \sin\theta$$

As the angle is very small, i.e. $\sin\theta \simeq \tan\theta$

∴ $$\Delta P = d \tan\theta$$

From $\Delta\, POO'$; $\tan\theta = \frac{Y}{D}$

$$\Delta P = d\left(\frac{Y}{D}\right)$$

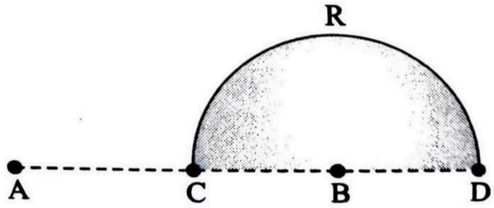
From equations (i) and (ii), we get that n^{th} maximum is ob

$$Y_n^{max} = \frac{n\lambda D}{d}$$

The separation between two consecutive maxima or minim width. So, fringe width is given by

$$\beta = Y_n^{max} - Y_{n-1}^{max} = \frac{\lambda D}{d}$$

A23 :



$V_C = 0$, **1/2M**

$V_D = \frac{1}{4\pi\epsilon_0}(q/L - q/3L) = \frac{1}{4\pi\epsilon_0}(2q/3L)$ **1.5M**

$W = Q\,[V_D - V_C] = \frac{-Qq}{6\pi\varepsilon_0 L}$ **1M**

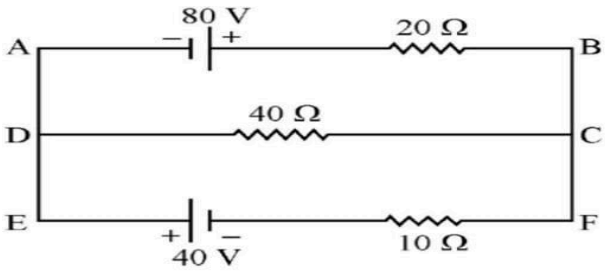
A24 : formula K= -E , U = -2K **1M**

(a) K = 13.6 eV

(b) U= - 27.2 eV **1M**

(c) The kinetic energy of the electron will not change. The value of potential energy and Consequently , the value of total energy of the electron will change. **1M**

A25:



Using Kirchhoff's rules to loop ABCDA

$80 - 20I_1 - 40(I_1 - I_2) = 0$

$60I_1 + 40I_2 = 80$ ……….(1) **1M**

Applying Kirchhoff's rules to loop FEDCF

$40 + 40(I_1 - I_2) - 10I_2 = 0$ $40I_1 - 50I_2 = -40$ ……….(2) **1M**

Solving equation (1) and (2) we get

$I_1 = 4A \text{ and } I_2 = 4A$

$\therefore$ Current through 40Ω resister is $I_1 - I_2 = 4 - 4 = 0$A **1M**

A26. **(a) Principle:** A current carrying coil when placed in a magnetic field experience a torque. **1/2M**

Working: Torque on coil due to current τ = NIBA **1.5 M**

where N is the number of turns, A is the area of coil.

If k is torsional rigidity of material of suspension wire, then for deflection ∅, restoring torque τ_r.

For equilibrium NIAB = k ∅

Clearly ∅ ∝ I , Hence a linear scale is used to determine the deflection of coil.

Clearly, deflection in galvanometer is directly proportional to current, scale of galvanometer is linear.

(b) Concave magnets are used to produce radial magnetic field- The angle between the normal of the plane of loop and magnetic field becomes $\theta = 90^o$, to produce maximum torque. when radial magnetic field is used the deflection of coil is proportional to the current flowing through it. **1M**

A27: (a) Microwaves > Infrared rays > Ultraviolet radiation > g-rays **1M**

(b) **(i)** Microwaves : Radar communication, study of atomic structure ½ M

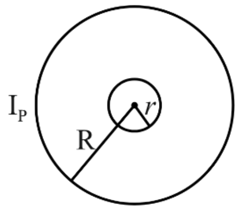
(ii) Infrared rays: Elucidating molecular structure , haze photography ½ M

(iii) Ultraviolet radiation: Photo electric Effect, Tanning of skin ½ M

(iv) g-rays : Photo electric Effect, X- ray of bones, Medical uses ½ M

A28:(a) : Mutual Inductance (M): The property quantifying the induced EMF in one coil due to the rate of change of current in another coil. S.I. Unit is Henry. ½ M+ ½M

(b)



Let a current I_P flow through the circular loop of radius R. The magnetic induction at the centre of the loop is

$$B_P = \frac{\mu_0 I_P}{2R}$$ **½ M**

As, $r << R$, the magnetic induction B_P may be considered to be constant over the entire cross sectional area of inner loop of radius r. Hence magnetic flux linked with the smaller loop will be

$$\phi_S = B_P A_S = \frac{\mu_0 I_P}{2R}\pi r^2$$ **1M**

Also , $\emptyset s = M\,Ip$ **½ M**

$$M = \frac{\phi_S}{I_P} = \frac{\mu_0 \pi r^2}{2R}$$ **1M**

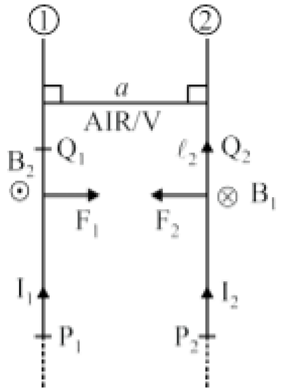
OR

The magnetic induction B_1 set up by the current I_1 flowing in first conductor at a point somewhere in the middle of second conductor is

$$B_1 = \frac{\mu_0 I_1}{2\pi a} \quad ...(1)$$

½

M



The magnetic force acting on the portion P_2Q_2 of length ℓ_2 of second conductor is

$F_2 = I_2 \ell_2 B_1 \sin 90°$

From equation (1) and (2), ...(2)

$F_2 = \dfrac{\mu_0 \ldots}{2\pi a}$, towards first conductor

½ M

$\dfrac{F_2}{\ell_2} = \ldots$ ...(3)

The magnetic induction B_2 set up by the current I_2 flowing in second conductor at a point somewhere in the middle of first conductor is

$$B_2 = \frac{\mu_0 I_2}{2\pi a}$$ ...(4)

½ M

The magnetic force acting on the portion P_1Q_1 of length ℓ_1 of first conductor is

$F_1 = I_1 \ell_1 B_2 \sin 90°$ ...(5)

From equation (3) and (5)

$$F_1 = \frac{\mu_0 I_1 I_2 \ell_1}{2\pi a}$$, towards second conductor

½ M

$\dfrac{F_1}{\ell_1} = \dfrac{\mu_0 I_1 I_2}{2\pi a}$ ... (6)

(b) (i) Attractive ½ M

(ii) Repulsive ½ M

SECTION-D

- **1 Mark for each correct answer**

A29. (i) b (ii) c (iii) a (iv) b OR a

A 30. (i) d (ii) c (iii) a (iv) b OR a

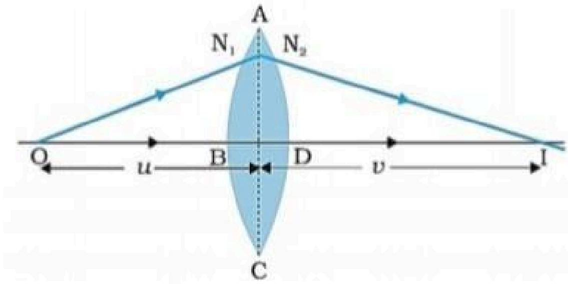
SECTION E

A31: i. DIAGRAM/S : 1M

DERIVATION : 2M

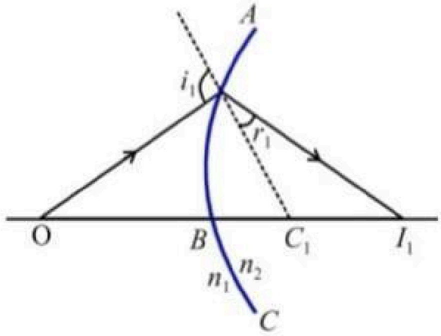
NUMERICAL : 2 M

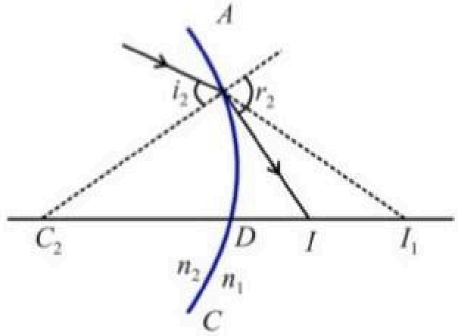
Lens maker's Formula

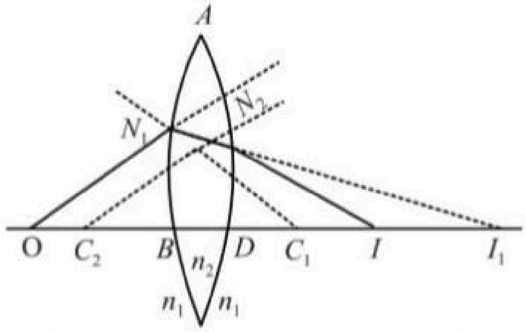


When a ray refracts from a lens (double convex), in above figure, then its image formation can be seen in term of two steps :

Step 1: The first refracting surface forms the image I_1 of the object O







Step 2: The image of object O for first surface acts like a virtual object for the second surface. Now for the first surface ABC, ray will move from rarer to denser medium, then

$$\frac{n_2}{BI_1} + \frac{n_1}{OB} = \frac{n_2 - n_1}{BC_1} \quad \text{...(i)}$$ ½ M

Similarly for the second interface, ADC we can write.

$$\frac{n_1}{DI} - \frac{n_2}{DI_1} = \frac{n_2 - n_1}{DC_2} \quad \text{...(ii)}$$ ½ M

DI_1 is negative as distance is measured against the direction of incident light.

Adding equation (1) and equation (2), we get

$$\frac{n_2}{BI_1} + \frac{n_1}{OB} + \frac{n_1}{DI} - \frac{n_2}{DI_1} = \frac{n_2 - n_1}{BC_1} + \frac{n_2 - n_1}{DC_2}$$

or $$\frac{n_1}{DI} + \frac{n_1}{OB} = (n_2 - n_1)\left(\frac{1}{BC_1} + \frac{1}{DC_2}\right)$$ ...(iii) ($\because$ for thin lens $BI_1 = DI_1$)

Now, if we assume the object to be at infinity *i.e.* $OB \to \infty$, then its image will form at focus F (with focal length f), *i.e.* ½ M

$DI = f$, thus equation (iii) can be rewritten as

$$\frac{n_1}{f} + \frac{n_1}{\infty} = (n_2 - n_1)\left(\frac{1}{BC_1} + \frac{1}{DC_2}\right)$$

or $$\frac{n_1}{f} = (n_2 - n_1)\left(\frac{1}{BC_1} + \frac{1}{DC_2}\right) \quad \text{...(iv)}$$

Now according to the sign conventions

$BC_1 = +R_1$ and $DC_2 = -R_2$ ...(v) ½ M

Substituting equation (v) in equation (iv), we get

$$\frac{n_1}{f} = (n_2 - n_1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = (n_{21} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

(ii) $$\frac{1}{f_a} = (1.6 - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \text{...(1)}$$ **1M**

$$\frac{1}{f_\ell} = \left[\frac{1.6}{1.3} - 1\right]\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \text{....(2)}$$ **1M**

From equation (1) and (2)

$$\frac{f_\ell}{f_a} = \left[\frac{0.6}{0.3} \times 1.3\right] \Rightarrow f_\ell = 2.6 \times 10\,\text{cm} \Rightarrow f_\ell = 26\,\text{cm}$$

OR

(a) wavefront is defined as a surface of constant phase.

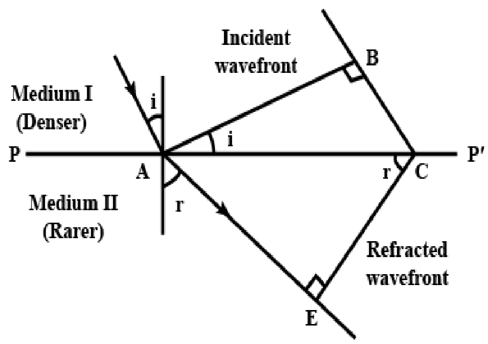
The ray indicates the direction of propagation of wave while the wavefront is the surface of constant phase.

The ray at each point of a wavefront is normal to the wavefront at that point.

1M

(b) AB: Incident Plane Wave Front & CE is Refracted Wave front . **2M**

Sin i = BC/AC & Sin r = AE /AC

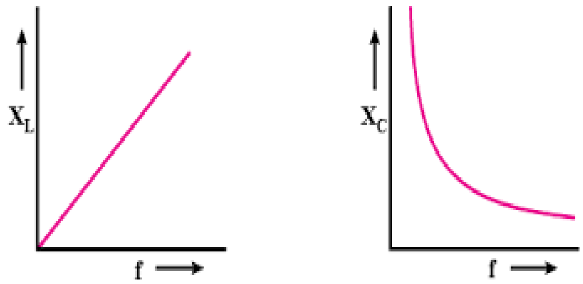


Sin i / Sinr = BC /AE $= v_1 / v_2 =$ constant

(c) $\theta = \lambda / a$ i.e. $\theta = \frac{\lambda}{a} = \frac{6\times10^{-7}}{0.1\times\frac{\pi}{180}} = 3.4\times10^{-4}$ m **1M**

(d) Two differences between interference pattern and diffraction pattern. **1M**

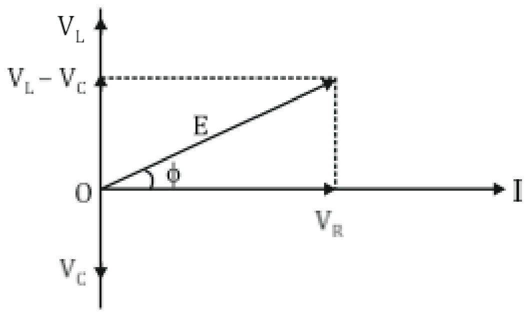
A32. (a)



(a) (b)

½ + ½ M

(b)



1M

(c) (i) In device X, Current lags behind the voltage by $\pi/2$, X is an inductor

In device Y, Current in phase with the applied voltage, Y is resistor **½ + ½ M**

(ii) We are given that

$I = V_L / X_L$

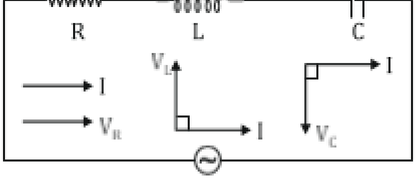
$0.25 = 220/X_L$, $X_L = 880\Omega$, Also $0.25 = 220/R$, $R = 880\Omega$ **1M**

For the series combination of X and Y,

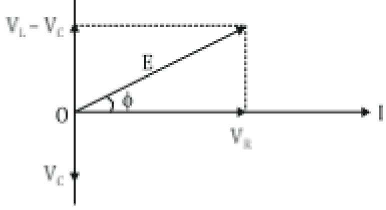
Equivalent impedance $Z = 880\sqrt{2}\ \Omega$, $I = 0.177$ A **1M**

OR

(a).



LCR Circuit



1M

$E = E_0 \sin\omega t$ is applied to a series LCR circuit. Since all three of them are connected in series the current through them is same. But the voltage across each element has a different phase relation with current. The potential difference V_L, V_C and V_R across L, C and R at any instant is given by

$V_L = I X_L$, $V_C = I X_C$ and $V_R = IR$, where I is the current at that instant.

V_R is in phase with I. V_L leads I by 90° and V_C lags behind I by 90° so the phasor diagram will be as shown

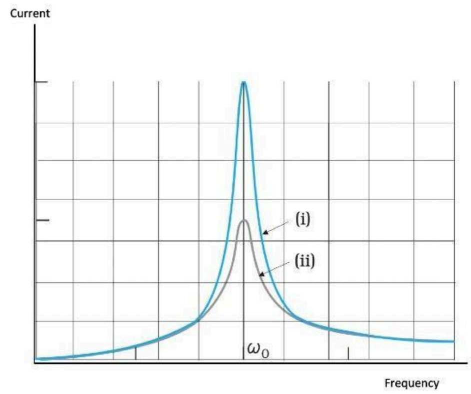
Assuming $V_L > V_C$, the applied emf E which is equal to resultant of potential drop across R, L & C is given as $E^2 = I^2 [R^2 + (X_L - X_C)^2]$

Or $I = \frac{E}{\sqrt{[R^2 + (X_L - X_C)^2]}} = \frac{E}{Z}$, where Z is Impedance.

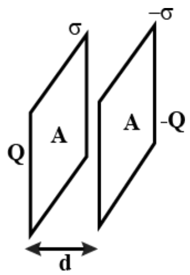
3M

Emf leads current by a phase angle φ as $\tan\varphi = \frac{V_L - V_C}{R} = \frac{X_L - X_C}{R}$

(b). The curve (i) is for R_1 and the curve (ii) is for R_2 **1M**



A33: **(i)** Derivation of the expression for the capacitance **2M**



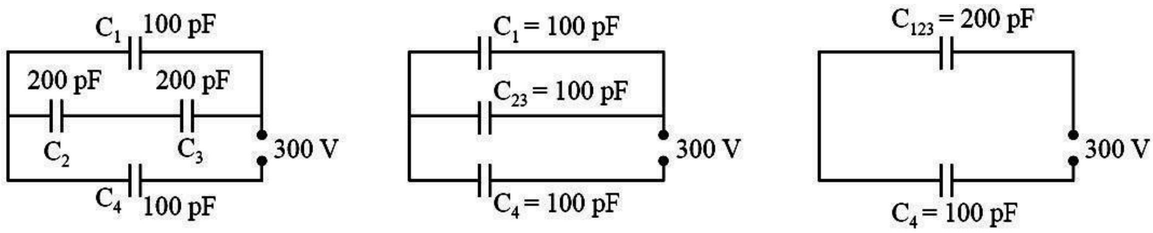
Let the two plates be kept parallel to each other separated by a distance d and cross-sectional area of each plate is A. Electric field by a single thin plate $E = \sigma / 2\epsilon_0$

Total electric field between the plates $E = \sigma / \epsilon_0 = Q/A\epsilon_0$

Potential difference between the plates $V = Ed = [Q/A\epsilon_0]\, d$.

Capacitance $C = Q / V = A\epsilon_0 / d$

(ii)



1 M

The equivalent capacitance =

0 3

pF

charge on C4 = $\frac{200}{3} \times 10^{-12} \times 300$= 2 × 10^{-8} C, **½ M**

potential difference across C_4 = $\frac{200 \times 10^{-12} \times 300}{3 \times 100 \times 10^{-12}}$ = 200 V

potential difference across C_1 = 300 – 200 = 100 V

charge on C_1 = 100 × 10^{-12} × 100 = 1 × 10^{-8} C **½ M**

potential difference across C_2 and C_3 series combination = 100 V

potential difference across C_2 and C_3 each = 50 V

charge on C_2 and C_3 each = 200 × 10^{-12} × 50 = 1 × 10^{-8} C **½+½ M**

OR

(a) Capacitance decreases : Capacitance is inversely proportional to the distance of separation.

(b) Charge decreases : From Q = CV, C decreases and V remains the same, so Q decreases.

(c) Potential difference remains the same : As the capacitor is connected to the battery, the potential V of the capacitor will remain the same as that of the battery.

(d) Electric field decreases : E due to a plane sheet of charge = σ/ϵ_0 is independent of the distance from the sheet. But charge density σ on the plate decreases, so E decreases.

(e) Energy stored in the capacitor decreases : Energy stored is proportional to both Q and V. Charge Q decreases but potential V is constant.

#1/2 M FOR IDENTIFICATON (INCRESE/DECREASE/REMAIN SAME) & ½ M FOR CORRECT REASONING.