RSITÉ D'OTTAWA
RSITY OF OTTAWA

With Solutions

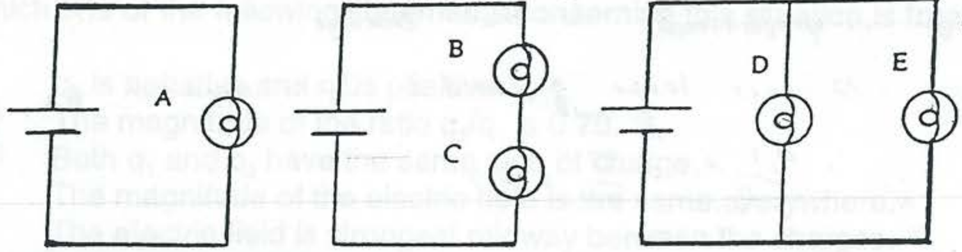
DES SCIENCES
Y OF SCIENCE

PHY 1102A

April 20, 2005 | **Dr. Z.M. Stadnik**
Final Open-Book Examination: 3 hours |

The answers should be entered carefully on a computer readable sheet using an HB <u>pencil</u>. At the end of the examination, only the computer sheet should be handed over to a proctor. The student can keep this questionnaire.

1.



The three circuits above have the same battery and the light bulbs in each circuit have the same resistance. Rank the bulbs in the circuits in the order of brightness, from largest to smallest.

A) B = C > A = D = E
B) B = C > A > D = E
C) B = C > D = E > A
D) A = D = E > B = C
E) A = B = C = D = E

2. The capacitance of a parallel-plate capacitor can be increased by

A) increasing the charge.
B) decreasing the charge.
C) decreasing the plate area.
D) increasing the plate separation.
E) decreasing the plate separation.

PHYSIQUE
150 LOUIS-PASTEUR CP 450 SUCC A
OTTAWA ON K1N 6N5 CANADA

PHYSICS
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1. $P = I^2R$: measure of brightness

$I_A = \frac{\varepsilon}{R}$, $I_B = I_C = \frac{\varepsilon}{2R}$, $I_D = I_E = \frac{\varepsilon}{R}$

$\therefore I_A = I_D = I_E > I_B = I_C \Rightarrow P_A = P_D = P_E > P_B = P_C$

2. $C = k\frac{\varepsilon_0 A}{d} \Rightarrow C \propto \frac{1}{d}$

The capitance to increase, seperation must decrease.

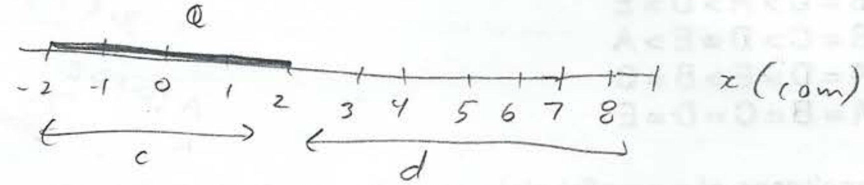
3. The number of Electric field lines leaving or approaching a change is proportional to that change.

10 lines leave q_1 and 7 lines approach q_2.

$\therefore \frac{q_2}{q_1} = \frac{7}{10} = 0.7$

answer : B

4.



$Q = 20nC = 20 \times 10^{-9}C$

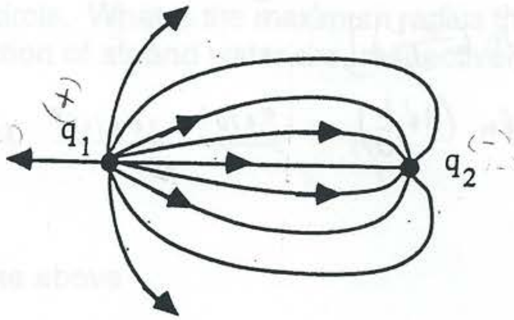
$d = 10^{-4} = 6,\ b = 4.$

$dq = \lambda dx$

$V(P) = ?$

$V = k\int_0^L \frac{dq}{x} = k\int_0^L \frac{\lambda dx}{d + L - x}$

3.



The figure above shows the electric field lines in the vicinity of two point charges. Which one of the following statements concerning this situation is true?

A) q_1 is negative and q_2 is positive.
B) The magnitude of the ratio q_2/q_1 is 0.70.
C) Both q_1 and q_2 have the same sign of charge.
D) The magnitude of the electric field is the same everywhere.
E) The electric field is strongest midway between the charges.

4. A charge of 20 nC is distributed uniformly along the x-axis from x = −2.0 m to x = 2.0 m. What is the electric potential (relative to zero at infinity) at the point x = 8.0 m on the x-axis?

A) 57 V
B) 41 V
C) 23 V
D) 13 V
E) zero

5. A swimmer, who is looking up from under the water, sees a diving board directly above at an apparent height of 4.0 m above the water. The indices of refraction of air and water are, respectively, 1.00 and 1.33. What is the actual height of the diving board?

A) 3.0 m
B) 5.3 m
C) 4.0 m
D) 3.5 m
E) none of the above

4. $\int \frac{dx}{a+bx} = \frac{1}{b}\ln(a+bx)$

$a = d+L,\ b = -1$

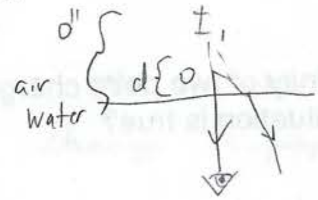
$V = k\lambda\left[-\ln(d+l-x)\right]_0^2$

$= k\lambda\ \left[-\ln d + \ln(d+L)\right]$

$= k\lambda\left[\ln\left(\frac{d+L}{d}\right)\right]$

$= \frac{kQ}{l}\ \ln\left(1+\frac{L}{d}\right) = \frac{9\times10^9 \times 20\times10^{-9}}{4}\ \ln\left(1+\frac{4}{6}\right) = 22.9V$

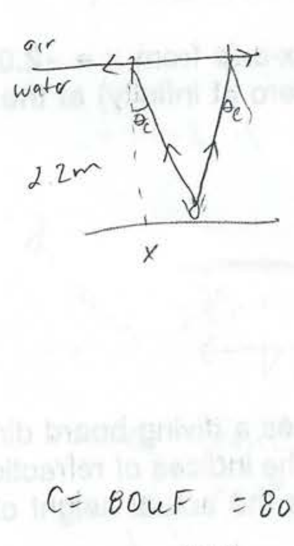
5.



$d' = \frac{n_{air}}{n_{water}}\ d$

$= \frac{1}{1.33} \times 4 = 3m$

6.



$\sin\theta_c = \frac{n_{air}}{n_{water}} = \theta_c = \arcsin\left(\frac{n_{air}}{n_{water}}\right)$

$\theta_c = \arcsin\left(\frac{1}{1.33}\right) = 48.75°$

$\frac{x}{2.2} = \tan\theta_c$

$x = 2.2\tan\ 48.75°$

$= 2.508m$

7. $C = 80uF = 80\times10^{-6}F$

$R = 45\Omega$

$f = 30\% \quad = 0.03$

$f = \frac{U_0 - U}{U_0} \Rightarrow U_0(1-f) = U$

$U_0 = \frac{1}{2}\frac{Q^2}{C}$; $U = \frac{1}{2}\frac{q^2}{C}$

$\frac{1}{2}\frac{Q^2}{C}(1-f) = \frac{1}{2}\frac{q^2}{C}$

$q = \sqrt{1-f}\ \ Q$

$q = Qe^{-t/RC}$

$\sqrt{1-f}\ Q = Q\ R^{-t/RC}$

$\frac{1}{2}\ln(1-f) = -\frac{t}{RC} \Rightarrow t = \frac{-RC}{2}\ \ln(1-f)$

$t = \frac{-45\times80\times10^{-6}}{2}\ \ln(1-0.03) = 0.64ms$

6. A point source of light is submerged 2.2 m below the surface of a lake and emits light in all directions. On the surface of the lake, directly above the source, the area illuminated is a circle. What is the maximum radius that this circle could have? The indices of refraction of air and water are, respectively, 1.00 and 1.33.

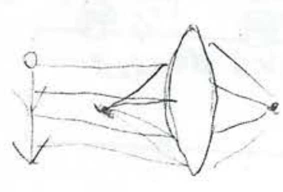
A) 1.7 m
B) 1.5 m
C) 2.5 m
D) 1.9 m
E) none of the above

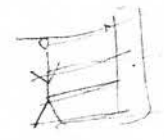
7. How long will it take a charged 80 μF capacitor to lose 30% of its initial energy if it is allowed to discharge through a 45 Ω resistor?

A) 0.64 ms
B) 2.2 ms
C) 1.3 ms
D) 0.32 ms
E) none of the above

8. Which one of the following statements concerning a convex mirror is true?

A) It can form a real image.
B) It must be spherical in shape.
C) The image will always be inverted relative to the object.
D) It produces a larger image than does a plane mirror for the same object distance.
E) The image it produces is closer to the mirror than it would be in a plane mirror for the same object distance.





9) $C_{23} = C_2 + C_3 = 10 + 20 = 30\,uF$

$C_{eq} = \dfrac{C_{23} C_1}{C_{23} + C_1} = \dfrac{30 \times 15}{30 + 15} = 10 uF$

$Q_1 = Q_{23} = C_{eq} V = 10 \times 18 = 180 uC$

$V_{23} = V_2 = V_3 \quad \dfrac{Q_{23}}{C_{23}} = \dfrac{180 uC}{30 uF} = 6V$

$U_3 = \frac{1}{2} C_3 V_3^2 = \frac{1}{2} \times 20 \times 10^{-6} \times 6^2 = 3.6 \times 10^{-4} J = 0.36 mJ$ a.

10. $V_p = V_0 - \dfrac{6}{2\varepsilon_0} |x|$ for infinite non conducting plate.

$V_p - V_0 = \dfrac{-6}{2\varepsilon_0} |x| \Rightarrow \Delta V = \dfrac{-6}{2\varepsilon_0} |x|$

$= \dfrac{-(-88.5 \times 10^{-9})}{2 \times 8.85 \times 10^{-12}} \times 20 \times 10^{-2} = 1000 V$

11. When the switch is closed the current will flow through the switch which has less resistance ~~than the bulb~~ then A will be brighter

13. For no net electric field outside the system, the charge on the pipes must be equal in magnitude and opposite in sign.

$\therefore Q_{out} = Q_{in} = -6 uC$

$\sigma_{out} = \dfrac{Q_{out}}{A_{out}} = \dfrac{Q_{out}}{2\pi r h} = \dfrac{-6}{2\pi \times 3 \times 10^{-2} \times 3} = -10.61 uC/m^2$

14. $V = \dfrac{KQ}{r}, \; r' = \dfrac{r}{2} \Rightarrow V' = \dfrac{KQ}{r'} = \dfrac{KQ}{r/2} = \dfrac{2KQ}{r} = 2V$

$V' = 2V \Rightarrow$ doubled.

15. q inside the conductor $= 0$

$q_1 + q_2 = 0$

$q_2 = -q_1 = -6 uC$

q outside of the conductor $= +6 uC$

$q_2 + q_3 = +6 uC$

$q_3 = +6 - q_2$

$= +6 - (-6)$

$= +12 uC$

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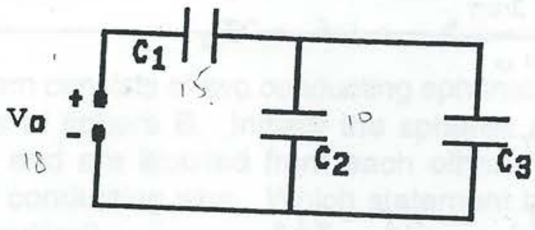
9.



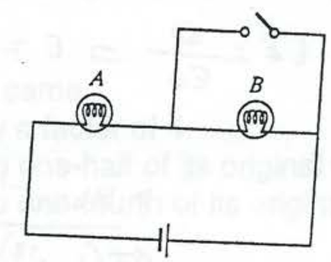
If $C_1 = 15$ μF, $C_2 = 10$ μF, $C_3 = 20$ μF, and $V_o = 18$ V, determine energy stored by C_3.

A) 0.18 mJ
B) 0.36 mJ
C) 0.72 mJ
D) 0.54 mJ
E) none of the above

10. Two nonconducting charged sheets carry equal but opposite surface charge densities ± 88.5 nC/m². The negative sheet is located at $x = 0$, and positive sheet at $x = 10$ cm. The potential difference from the negative sheet to the points $x = 20$ cm is

A) 100 V.
B) 500 V.
C) 2000 V.
D) 1000 V.
E) none of the above

11. The circuit below consists of two identical light bulbs burning with equal brightness and a single 12 V battery. When the switch is closed, the brightness of bulb *A*



A) decreases.
B) remains unchanged.
C) increases.

16) $10 - 10I_1 - 20I_2 = 0$

$15 - 10I_3 - 20I_2 = 0$

$I_1 = 20I_2 - 10 = 2I_2 - 1$

$I_3 = \frac{15 - 20I_2}{10} = 1.5 - 2I_2$

$I_1 + I_2 = I_3$

$2I_2 - 1 + I_2 = 1.5 - 2I_2$

$5I_2 = 2.5$

$I_2 = 0.5\ A$

17. a neutral (uncharged) particle will not be deflected by the electric field

18. $E = k\frac{q}{y_0^2} = \frac{9\times10^9 \cdot 75\times10^{-9}}{4^2} = 42.19$

$E = k\frac{q}{x_0^2 + y_0^2} = \frac{9\times10^9 \cdot (8\times10^{-9})}{4^2 + 3^2} = 2.88$

$42.19 \times \frac{4}{5} = 33.7$

20) $Q = q_1 + q_2 = 5 + 3 = 8\,pC = 8\times10^{-12}\,C$

$\oint E\,dA = \frac{Q}{\varepsilon_0}$ $\quad EA = \frac{Q}{\varepsilon_0} \Rightarrow E = \frac{Q}{A\varepsilon_0} = \frac{Q}{4\pi r^2 \varepsilon_0}$

$= \frac{8\times10^{-12}}{4\pi(3\times10^{-2})^2 \times 8.85\times10^{-2}}$

$= 80\ N/C$

12. An isolated system consists of two conducting spheres **A** and **B**. Sphere **A** has five times the radius of sphere **B**. Initially the spheres are given equal amounts of positive charge and are isolated from each other. The two spheres are then connected by a conducting wire. Which statement is true *after* the spheres are connected by the wire?

Elec

A) Both spheres are at the same electric potential.
B) The electric potential of **A** is 1/25 as large as that of **B**.
C) The electric potential of **A** is 25 times larger than that of **B**.
D) The electric potential of **A** is 1/5 as large as that of **B**.
E) The electric potential of **A** is five times larger than that of **B**.

13. A thin-walled pipe 3.0 m long and 2.0 cm in radius carries a net charge 6.0 μC distributed uniformly over its surface. This pipe is surrounded concentrically by a second pipe of the same length and 3.0 cm in radius. What should be the surface charge density on this outer pipe in order that there be no electric field outside the entire structure?

Elec

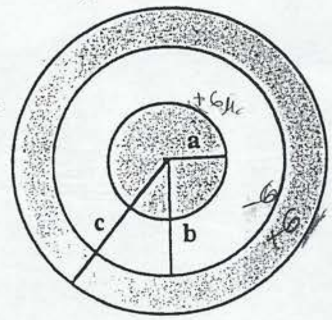
A) $-10.6\ \mu C/m^2$
B) $10.6\ \mu C/m^2$
C) $-5.3\ \mu C/m^2$
D) $5.3\ \mu C/m^2$
E) none of the above

14. Two positive point charges Q and q are separated by a distance R. If the distance between the charges is reduced to $R/2$, what happens to the total electric potential energy of the system?

Elec

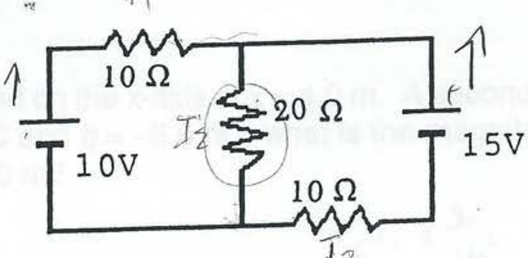
A) It is doubled.
B) It remains the same.
C) It increases by a factor of 4.
D) It is reduced to one-half of its original value.
E) It is reduced to one-fourth of its original value.

15. A solid conducting sphere of radius **a** carries an excess charge of +6 μC. This sphere is located at the center of a hollow conducting sphere with an inner radius of **b** and an outer radius of **c**, as shown in the figure below. The hollow sphere also carries a total excess charge of +6 μC. The excess charge on the *outer surface* of the outer sphere (a distance **c** from the center of the system) is



A) -6 μC.
B) +6 μC.
C) zero
D) +12 μC.
E) -12 μC.

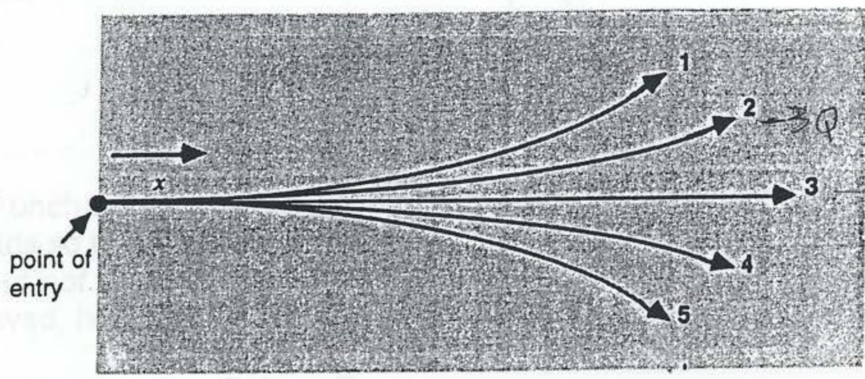
16.



What is the magnitude of the current in the 20-Ω resistor?

A) 0.75 A
B) 0.00 A
C) 0.25 A
D) 0.50 A
E) none of the above

17. Five particles are shot from the left into a region that contains a uniform electric field. The numbered lines below show the paths taken by the five particles. A particle of charge $-3Q$ follows path **2** while it moves through this field.



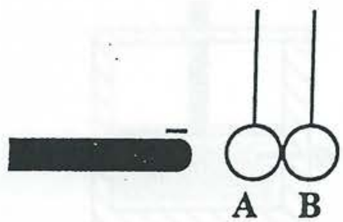
Which path would be followed by a neutral helium atom?

A) path **1**
B) path **2**
C) path **3**
D) path **4**
E) path **5**

18. A charge Q is placed on the x-axis at x = 4.0 m. A second charge q is located at the origin. If Q = 75 nC and q = −8.0 nC, what is the magnitude of the electric field on the y axis at y = 3.0 m?

A) 19 N/C
B) 23 N/C
C) 32 N/C
D) 35 N/C
E) none of the above

19.



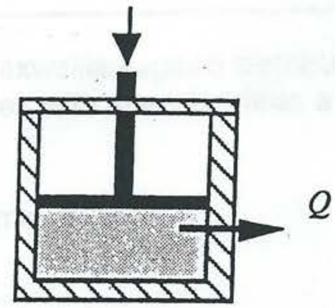
Two uncharged conducting spheres, **A** and **B**, are suspended from insulating threads so that they touch each other. While a negatively charged rod is held *near to, but not touching* sphere **A**, the two spheres are separated. If the rod is not removed, how will the spheres be charged, *if at all*?

	Sphere A	Sphere B
A)	0	+
B)	–	+
C)	0	0
D)	–	0
E)	+	–

20. A point charge 5.0 pC is located at the center of a spherical surface of radius 2.0 cm, and a charge of 3.0 pC is spread uniformly upon this surface. The magnitude of the electric field 3.0 cm from the point charge is

A) 90 N/C.
B) 30 N/C.
C) 80 N/C.
D) 40 N/C.
E) none of the above

21.



Enclosed beneath the moveable piston in the figure is 1.5 moles of a monatomic ideal gas at 314 K. The initial volume of the gas is 3.0 m^3. The gas is compressed isothermally to a final volume of 1.0 m^3. How much heat is removed from the gas?

A) -6450 J
B) -4300 J
C) -2900 J
D) -1450 J
E) zero

22. The temperatures of two identical gases are increased from the same initial temperature to the same final temperature. Reversible processes are used. For gas *A* the process is carried out at constant volume while for gas *B* it is carried out at constant pressure. The change in entropy

A) is greater for *A*.
B) is greater for *B*.
C) is the same for *A* and *B*.
D) is greater for *A* only if the initial temperature is low.
E) is greater for *A* only if the initial temperature is high.

23. A perfectly reversible heat pump supplies heat to a building to maintain its temperature at 27 °C. The cold reservoir is a river at 7 °C. If work is supplied to the pump at the rate of 1 kW, at what rate does the pump supply heat to the building?

A) 15 kW
B) 3.85 kW
C) 1.35 kW
D) 1.07 kW
E) 1.02 kW

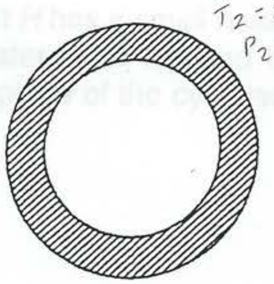
24. According to the Maxwellian speed distribution, as the temperature increases the number of molecules with speeds within a small interval near the most probable speed

A) stays the same.
B) increases.
C) decreases.

25. A certain ideal gas has a temperature of 300 K and a pressure 5.0×10^4 Pa. The molecules have a mean free path of 4.0×10^{-7} m. If the temperature is raised to 500 K and the pressure is reduced to 1.0×10^4 Pa, then the mean free path (in m) is

A) 4.0×10^{-7}.
B) 8.0×10^{-7}.
C) 1.0×10^{-6}.
D) 1.2×10^{-6}.
E) 3.3×10^{-6}.

26.



An annular ring of aluminum shown above is cut from an aluminum sheet. When this ring is heated,

A) linear expansion forces the shape of the hole to be slightly elliptical.
B) the aluminum expands outward and the hole remains the same in size.
C) the hole decreases in diameter.
D) the area of the hole expands the same percent as any area of the aluminum.
E) the area of the hole expands a greater percent than any area of the aluminum.

Since the ring will expand equally in all directions, the area of the hole will expand at an equal rate.

27. A wooden cube of side 0.1 m is just submerged in water when pressed down with a force of 3.43 N. The density (in kg/m^3) of the wood is

A) 650.
B) 350.
C) 250.
D) 150.
E) none of the above

28. A block of ice at 0 °C is floating on the surface of ice water in a beaker. The surface of the water just comes to the top of the beaker. When the ice melts, the water level will

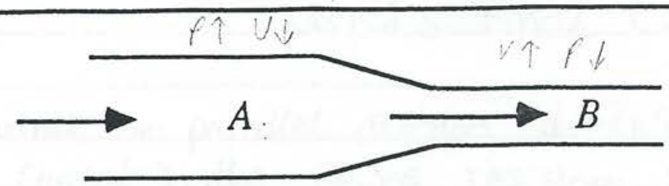
A) rise and overflow will occur.
B) remain the same.
C) fall.
D) depend on the initial ratio of water to ice.
E) depend on the shape of the block of ice.

29. A glass cylinder of height H has a small hole at a distance $H/2$ above its base. The cylinder is filled with water to its top and the waters spurts from the hole. The horizontal range (in the plane of the cylinder base) is

A) $H/\sqrt{2}$.
B) $H/2$.
C) $H/\sqrt{3}$.
D) H.
E) $\sqrt{3}\,H/2$.

30.

Fluid



Water flows through the pipe shown in the figure. The pressure

A) is greater at *A* than at *B*.
B) at *A* equals that at *B*.
C) is less at *A* than at *B*.
D) at *A* is unrelated to that at *B*.
E) at *A* may be greater or less than that at *B* depending on the rate of flow.

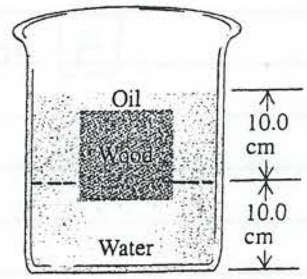
$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$

$P_1 - P_2 = \frac{1}{2}\rho(v_2^2 - v_1^2)$

so $P_1 - P_2 \sim (v_2^2 - v_1^2)$

31.

Fluid



A cubical block of wood 10.0 cm on a side floats at the interface between oil and water with its lower surface 2.00 cm below the interface, as shown in the figure above. The density of oil is 750 kg/m^3. The mass of the block is

A) 0.20 kg.
B) 0.80 kg.
C) 0.60 kg.
D) 0.96 kg.
E) 1.20 kg.

Volume submerged in water:

$V_w = 2 \times 10 \times 10 = 200 cm^3$

$= 200 \times 10^{-6} m^3$

Volume submerged in oil: $V_o =$

$8 \times 10 \times 10 = 800 cm^3$

$= 800 \times 10^{-6} m^3$

$\Sigma F_y = 0$

$F_{bo} + F_{bw} - w = 0$

$F_{bo} + F_{bw} = w$

$\rho_o V_o g + \rho_w V_w g = mg$

$\rho_o V_o = \rho_w V_w = m$

$m = 750 \times 800 \times 10^{-6} + 1000 \times 200 \times 10^{-6}$

$= 0.6 + 0.2$

$= 0.8 kg$.

Physics Final (2005)

① The current on parallel resistors doesn't split (it remains the same) but the current in the Series resistors splits among the resistors.

$\therefore A = D = E > B = C \Rightarrow$ Ans: D

② The capacitance of a parallel-plate capacitor can be increased by decreasing the plate separation

$$C = \frac{\varepsilon_0 A}{d}$$

A = area
d = distance or plate separation.

$\Rightarrow$ Ans :- E

③ $q_1 = 10 \quad q_2 = 7 \quad q_2 : q_1 = 7 : 10 = 0.7$

④ Solutions

Hilroy

(5)

(6)

(7) $Q = Q_0 \times e^{\left(\frac{-t}{RC}\right)}$

(8) [E] → table G0-24'

(9) $C_{(parallel)} = C_{23} = C_2 + C_3 = 10 + 20 = 30$

$\frac{1}{C_{eq}} = \frac{1}{30} + \frac{1}{15}$ ∴ $\boxed{C_{eq} = 10\mu F} = 10 \times 10^{-6} F$

$C = \frac{Q}{V}$ $10 \times 10^{-6} = \frac{Q}{18}$ ∴ $Q = 1.8 \times 10^{-4}$

$U = \left(\frac{1}{2}\right) \frac{(1.8 \times 10^{-4})^2}{?\ (20 \times 10^{-6})} =$

⇓

Solutions

(10) $V_P = V_0 = \frac{\sigma}{2\varepsilon_0}|x|$ for infinite nonconducting plate.

$\Delta V = \left(\frac{-\sigma}{2\varepsilon_0}\right)|x|$ (for negative; distance from negative to point)

$\Delta V = \left(\frac{-(-88.5 \times 10^{-9})}{2(8.8542 \times 10^{-12})}\right) |20 \times 10^{-2}| = \boxed{999.5\ V}$

$\simeq 1000$ $\boxed{D}$ is the answer

(11) A will be brighter

(12)

(13) $l_1 = 3m$ $R_1 = 2 \times 10^{-2}\ m$
$l_2 = 3m$ $R_2 = 3 \times 10^{-2}\ m$

For no net electric field outside of the system, the charges or the pipes must be equal in magnitude and opposite in sign.

$Q_{out} = -Q_{in} = -6\ \mu C$

$\sigma_{out} = \frac{Q_{out}}{A_{out}} = \frac{Q_{out}}{2\pi r_{out} h} = \frac{-6}{2\pi \times 3 \times 10^{-2} \times 3} = -10.61\ \mu C/m^2$

Ans :- $\boxed{A}$

(14) $V \sim \frac{1}{r}$

if $r = 1$ $V = \frac{1}{1}$

if $r = \frac{1}{2}$ $V = \frac{1}{1/2} = (1 \cdot 2) = 2$

∴ V will be doubled. [A]

(15) $-6 + x = 6$ ∴ $x = 6 + 6$ ⇒ $x = +12\,\mu C$

(16) $10 - 10(I_1) - 20I_2 = 0$ ⇒ $I_1 = (-10 + 20I_2)/-10$

$15 - 10I_3 - 20I_2 = 0$ ⇒ $I_3 = (20I_2 - 15)/-10$

∴ $I_1 = 2I_2 - 1$ ∴ $I_3 = 1.5 - 2I_2$

$I_1 + I_2 = I_3$

$2I_2 - 1 + I_2 = 1.5 - 2I_2$

$5I_2 = 2.5$

∴ $I_2 = 0.5A$

(17) path 3 ∴ [C]

A neutral (uncharged) particle will not be deflected by the electric field.

Hilroy

(18) $E^{+} = K \frac{|q|}{y_0^2} = \frac{(9\times10^9)(75\times10^{-9})}{4^2} = 42.19$

$E^{-} = K \frac{|q|}{x^2+y^2} = \frac{(9\times10^9)(8\times10^{-9})}{4^2+3^2} = 2.88$

$\left(\frac{42.19+2.08}{2}\right) = 22.5 \simeq$ **23 N/C** → **B**

(19) Sphere A (+) ; Sphere B (−) ∴ **E**

(20) $Q = q_1 + q_2 = 5+3 = 8\ pC = 8\times10^{-12}\ C$

$\oint E\,dA = \frac{Q}{\varepsilon_0}$

$EA = \frac{Q}{\varepsilon_0} \Rightarrow E = \frac{Q}{A\varepsilon_0}$

$= \frac{Q}{4\pi r^2 \varepsilon_0}$

$= \frac{8\times10^{-12}}{4\pi(3\times10^{-2})^2 \times 8.85\times10^{-12}}$

$= 80\ N/C$

$\Delta U = Q - W$

(21) In an Isothermal process, $\Delta U = 0$ ∴ $Q = W$

$$W = nRT \ln\left(\frac{V_f}{V_i}\right)$$

$$W = 1.5\,(8.314)(314) \ln\left(\frac{1}{3}\right) = -4302 \text{ Joules}$$

∴ **B**

(22) The entropy is greater for B, because entropy is no affected by change in pressure, it is affected by change in volume.

∴ **B**

(23) $T_H = 27^\circ C = 300.15K$ $T_c = 7^\circ C = 280.15K$

$W = 1KW$

$$\frac{Q_H}{W} = \frac{T_h}{T_h - T_c} \Rightarrow \frac{Q_H/t}{W/t} = \frac{T_H}{T_H - T_c}$$

$$\frac{P_H}{P_W} = \frac{T_H}{T_H - T_c} \Rightarrow P_H = \frac{T_H}{T_H - T_c} \times P_W$$

$$= \frac{300.15}{300.15 - 280.15} \times (1) \approx 15 KW$$

∴ **A**

Hilroy

(24) The speed will decrease (look at formula)

(25) $\lambda = \frac{1}{\sqrt{2}\,\pi\, d^2 \frac{N}{V}}$

(26) [D] → expansion.

(24) The speed will decrease (look at formula)

(25) $\lambda = \frac{1}{\sqrt{2}\,\pi d^2 \frac{N}{V}}$

(26) [D] → expansion.

(30) Velocity in A is less;

thus; pressure in V is more in A => [A]

(31) $m = \rho V$

FBD

volume of wood in water

$V_w = (2\times10^{-2})(10\times10^{-2})(10\times10^{-2})$

$V_w = 2\times10^{-4}\ m^3$

Volume of wood in oil

$V_{oil} = (8\times10^{-2})(10\times10^{-2})(10\times10^{-2})$

$V_{oil} = 8\times10^{-4}\ m^3$

$\Sigma F_y = 0: \quad F_{B_o} + F_{B_w} = w$

$\Rightarrow F_{B_o} + F_{B_w} = mg$

$\Rightarrow \rho_o V_o g + \rho_w V_w g = mg$

$\Rightarrow g(\rho_o V_o + \rho_w V_w) = mg$

$\Rightarrow 750(8\times10^{-4}) + 1000(2\times10^{-4}) = m$

$\Rightarrow \boxed{m = 0.8\ Kg}$

Final Exam April 2005

1. $P = I^2R$: (measure of brightness)

$I_A = \frac{\mathcal{E}}{R}$, $I_B = I_C = \frac{\mathcal{E}}{2R}$, $I_D = I_E = \frac{\mathcal{E}}{R}$

$\therefore I_A = I_D = I_E > I_B = I_C \Rightarrow P_A = P_D = P_E > P_B = P_C$

2. $C = k\varepsilon_0 \frac{A}{d} \Rightarrow C \sim \frac{1}{d}$

For capacitance to increase, separation must decrease.

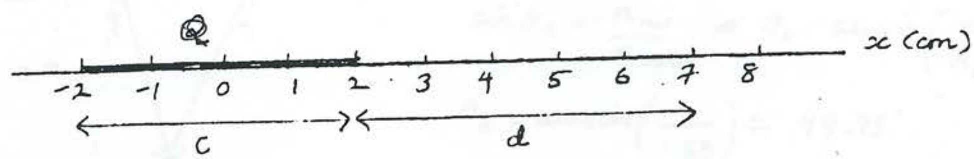
3. The number of electric field lines leaving or approaching a charge is proportional to that charge.

10 lines leave q_1 and 7 lines approach q_2

$\therefore q_2/q_1 = \frac{7}{10} = 0.7$

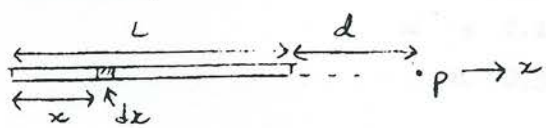
Answer: B

4.



$Q = 20nC = 20 \times 10^{-9} C$

$d = 10 - 4 = 6$, $L = 4$



$dq = \lambda dx$

$V_{(p)} = ?$

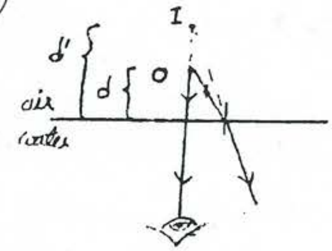
$$V = k\int_0^L \frac{dq}{r} = k\int_0^L \frac{\lambda dx}{d + L - x}$$

$$\int \frac{dx}{a+bx} = \frac{1}{b} \ln(a+bx)$$

$a = d+L$, $b = -1$

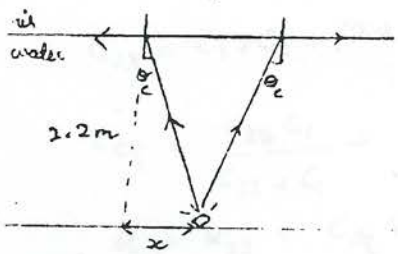
$$V = k\lambda\left[-\ln(d+L-x)\right]_0^L$$
$$= k\lambda\left[-\ln d + \ln(d+L)\right]$$
$$= k\lambda\left[\ln\left(\frac{d+L}{d}\right)\right]$$
$$= \frac{kQ}{\ell} \ln\left(1+\frac{L}{d}\right) = \frac{9\times10^9 \times 20\times10^{-9}}{4} \ln\left(1+\frac{4}{6}\right) = 22.9\,V$$

5.



$$d' = \frac{n_{air}}{n_{water}} d$$
$$= \frac{1}{1.33} \times 4 = 3\,m$$

6.



$$\sin\theta_c = \frac{n_{air}}{n_{water}} \Rightarrow \theta_c = \arcsin\left(\frac{n_{air}}{n_{water}}\right)$$
$$\theta_c = \arcsin\left(\frac{1}{1.33}\right) = 48.75^\circ$$
$$\frac{x}{2.2} = \tan\theta_c$$
$$x = 2.2 \tan 48.75^\circ$$
$$= 2.508\ m$$

7. $C = 80\,\mu F = 80\times10^{-6} F$

$R = 45\,\Omega$

$f = 30\,\% = 0.03$

$$f = \frac{U_0 - U}{U_0} \Rightarrow U_0(1-f) = U$$

$$U_0 = \frac{1}{2}\frac{Q^2}{C} \; ; \; U = \frac{1}{2}\frac{q^2}{C}$$

$$\frac{1}{2}\frac{Q^2}{C}(1-f) = \frac{1}{2}\frac{q^2}{C}$$

$$q = \sqrt{1-f}\, Q$$

but $$q = Q e^{-\frac{t}{RC}}$$

$$\therefore \quad \sqrt{1-f}\, Q = Q R^{-t/RC}$$

$$\frac{1}{2}\ln(1-f) = -\frac{t}{RC} \Rightarrow t = -\frac{RC}{2}\ln(1-f)$$

$$t = -\frac{45\times 80\times 10^{-6}}{2}\ln(1-0.03) = 0.64\ ms$$

8.

9. $$C_{23} = C_2 + C_3 = 10 + 20 = 30\mu F$$

$$C_{eq} = \frac{C_{23}C_1}{C_{23}+C_1} = \frac{30\times 15}{30+15} = 10\mu F$$

$$Q_1 = Q_{23} = C_{eq}V = 10\times 18 = 180\mu C$$

$$V_{23} = V_2 = V_3 = \frac{Q_{23}}{C_{23}} = \frac{180\mu V}{30\mu F} = 6V$$

$$U_3 = \frac{1}{2}C_3V_3^2 = \frac{1}{2}\times 20\times 10^{-6}\times 6^2 = 3.6\times 10^{-4}J = 0.36\ mJ$$

10 $$V_p = V_0 - \frac{\sigma}{2\varepsilon_0}|x|$$ for infinite nonconducting plate.

$$V_p - V_0 = \frac{-\sigma}{2\varepsilon_0}|x| \Rightarrow \Delta V = \frac{-\sigma}{2\varepsilon_0}|x|$$

$$= \frac{-(-88.5\times 10^{-9})}{2\times 8.85\times 10^{-12}}\times 20\times 10^{-2} = 1000V$$

11.) $R_{eq} = 6\,\Omega$, $I = 2\,A$

$P = (1.33)^2(2) \doteq 3.56\,W$ ∴ E

12.) D, common sense

13.) ✳ I_0

(‖) ↕ $\frac{1}{2} I_0$

(//) $I = (\frac{1}{2} I_0)\cos^2(45°) = \frac{1}{4} I_0$

(=) $I = (\frac{1}{4} I_0)\cos^2(45°) = \frac{1}{8}$ ∴ D

14.) $L = 20\,cm$, $t = 1.0\,\mu m$

$$\Delta x = (0.20\,m)\left(\frac{\frac{550\times10^{-9}\,m}{1.33}}{2(1.0\times10^{-6}\,m)}\right) = 4.14\,cm \quad E$$

15.) A

16.) B, velocity increases, pressure decreases.

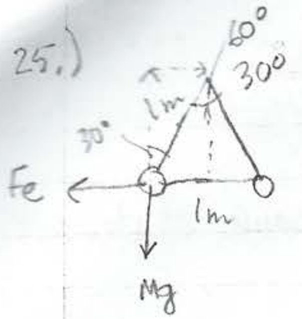
17.) $P(2V) = nR(2T)$, $PV = nRT$, unchanged.

∴ C

18.) $\Delta E_k = \frac{3}{2} K \Delta T = \frac{3}{2}(1.38\times10^{-23})(2T)$

∴ B

25.)



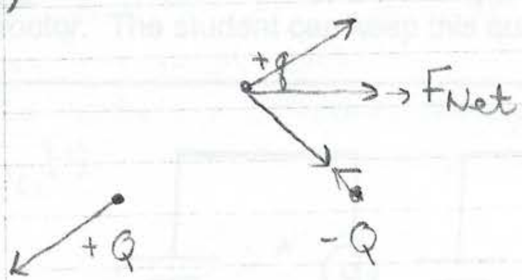
$\therefore r = 1m$

$mg = 9.8N$

$F_e = \frac{9.8N}{\cos(30°)} \sin(30°) = 5.658 N$

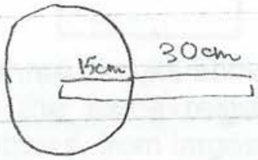
$5.658N = \frac{kQ^2}{(1)^2}$, $Q = 2.5 \times 10^{-5} C$ $\therefore$ A

26.)



$\therefore$ E

27.)



$800 = \frac{(9 \times 10^9) Q}{(0.3)^2}$

$Q = 8.0 \times 10^{-9} C$

$\sigma = \frac{8.0 \times 10^{-9} C}{(4\pi (0.15)^2)} = 2.83 \times 10^{-8} \frac{C}{m^2}$ $\therefore$ D

28.) C, connected by a wire so same potential

29.) $I = 3.5 A$, $V = (12 \Omega)(3.5A) = 42 V$

$P = \frac{V^2}{R} = \frac{(42)^2}{18\Omega} = 98 W$ $\therefore$ B

30.) $P = I^2 R \rightarrow A$, battery A should be hotter.
$P = I^2 r \rightarrow B$

Obviously not C or D, they are the same statement

$\therefore$ A

31.)

$$d = \frac{1}{550} \times \frac{1mm}{1000m} = 1.8182 \times 10^{-6} m$$