$$T\left({}^{o}C\right)=\frac{5}{9}\left(T\left({}^{o}F\right)-32\right)$$
$$T\left(K\right)=T\left({}^{o}C\right)+273.15$$
$$\Delta L=\alpha L_0\Delta T$$
$$\Delta V=\beta V_0\Delta T$$
$$Q=mc\Delta T=nC\Delta T$$
$$Q_{F/V}=\pm mL_{F/V}$$
$$H=\frac{dQ}{dt}=k\frac{A}{L}\left(T_H-T_C\right)$$
$$pV=nRT$$
$$K_{tr}=\frac{3}{2}nRT$$
$$C_V=\frac{3}{2}R \quad \text{ideal monatomic gas}$$
$$C_V=\frac{5}{2}R \quad \text{ideal diatomic gas w/o vibration}$$
$$W=\int_{V_1}^{V_2}p\,dV$$
$$\Delta U=Q-W$$
$$e=\frac{W}{Q_H}=1-\left|\frac{Q_C}{Q_H}\right|$$
$$e_{Carnot}=1-\left|\frac{T_C}{T_H}\right|$$
$$\Delta S=\int_1^2\frac{dQ}{T}$$
$$S=k\ln w$$
$$R=8.314\,J/mol\cdot K$$
$$N_A=6.02\times10^{23}\,molecules/mole$$
1 atm = 101 325 N / (m$^2$)
$1/4\pi\varepsilon_0$ = 8.99 x 10$^9$ Nm$^2$/C$^2$
e = -1.602 x 10$^{-19}$ C
$$\vec{F}_E=q\vec{E}=\frac{1}{4\pi\varepsilon_0}\frac{qQ}{r^2}\hat{r}$$
$$\Phi_E=\oint\vec{E}\cdot d\vec{A}=\frac{q_{enc}}{\varepsilon_0}$$
$$V_b-V_a=-\int_a^b\vec{E}\cdot d\vec{l}$$
$$\Delta U=q\Delta V$$
$$\vec{E}=-\left(\hat{i}\frac{\partial V}{\partial x}+\hat{j}\frac{\partial V}{\partial y}+\hat{k}\frac{\partial V}{\partial z}\right)$$
$$Q=CV$$
$$\frac{1}{C_{eq}}=\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}+\ldots \quad \text{series}$$
$$C_{eq}=C_1+C_2+C_3+\ldots \quad \text{parallel}$$
$$U=\frac{1}{2}CV^2$$
$$u_E=\frac{1}{2}\varepsilon_0E^2$$
$$E=\frac{E_0}{K}$$
$$I=\frac{dq}{dt}$$
$$\vec{J}=nq\vec{v}_d$$
$$\rho=\frac{E}{J}$$
$$V=IR$$
$$P=VI$$
$$R_{eq}=R_1+R_2+R_3+\ldots \quad \text{series}$$
$$\frac{1}{R_{eq}}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+\ldots \quad \text{parallel}$$
$$q=C\mathcal{E}\left(1-e^{-t/RC}\right) \quad \text{charging}$$
$$q=Q_0e^{-t/RC} \quad \text{discharging}$$
$$\vec{F}=q\vec{v}\times\vec{B}$$
$$\Phi_B=\int\vec{B}\cdot d\vec{A}$$
$$d\vec{F}=Id\vec{l}\times\vec{B}$$
$$\vec{\tau}=\vec{\mu}\times\vec{B},\quad \vec{\mu}=NI\vec{A}$$
$$U=-\vec{\mu}\cdot\vec{B}$$
$$\vec{B}=\frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$$
$$d\vec{B}=\frac{\mu_0}{4\pi}\frac{Id\vec{l}\times\hat{r}}{r^2}$$
$$\oint\vec{B}\cdot d\vec{l}=\mu_0\left(i_C+i_D\right)$$
$$\oint\vec{\mathrm{E}}\cdot d\vec{l}=\mathcal{E}=-\frac{d\Phi_B}{dt}$$

$$i_D = \varepsilon \frac{d\Phi_E}{dt}$$

$$\mathcal{E}_2 = -M\frac{di_1}{dt} \text{ and } \mathcal{E}_1 = -M\frac{di_2}{dt}$$

$$M = \frac{N_2\Phi_{B2}}{i_1} = \frac{N_1\Phi_{B1}}{i_2}$$

$$\mathcal{E} = -L\frac{di}{dt},$$

$$L = \frac{N\Phi_B}{i}$$

$$U = \frac{1}{2}LI^2 \quad , \quad u_E = \frac{1}{2\mu_0}B^2$$

$$\frac{di}{dt} = \frac{\mathcal{E}}{L}e^{-Rt/L}$$

$$\omega = \frac{1}{\sqrt{LC}}$$

$$I_{RMS} = \frac{1}{\sqrt{2}}I \quad \text{for } i = I\cos(\omega t)$$

$$V_{RMS} = \frac{1}{\sqrt{2}}V \quad \text{for } v = V\cos(\omega t)$$

$$V_R = IR$$

$$V_L = IX_L, \quad \text{where } X_L = \omega L$$

$$V_C = IX_C, \quad \text{where } X_C = \frac{1}{\omega C}$$

$$V = IZ, \quad \text{where } Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$P_{\text{Avg}} = \frac{1}{2}VI\cos\varphi, \quad \tan\varphi = \frac{X_L - X_C}{R}$$

$$V_s = V_p\frac{N_s}{N_p}$$

## Calculus

***Derivatives:***

$$\frac{d}{dx}x^n = nx^{n-1} \qquad \frac{d}{dx}\ln ax = \frac{1}{x} \qquad \frac{d}{dx}e^{ax} = ae^{ax}$$

$$\frac{d}{dx}\sin ax = a\cos ax \qquad \frac{d}{dx}\cos ax = -a\sin ax$$

***Integrals:***

$$\int x^n\,dx = \frac{x^{n+1}}{n+1} \quad (n \neq -1) \qquad \int \frac{dx}{x} = \ln x \qquad \int e^{ax}\,dx = \frac{1}{a}e^{ax}$$

$$\int \sin ax\,dx = -\frac{1}{a}\cos ax \qquad \int \cos ax\,dx = \frac{1}{a}\sin ax \qquad \int \frac{dx}{\sqrt{a^2 - x^2}} = \arcsin\frac{x}{a}$$

$$\int \frac{dx}{\sqrt{x^2 + a^2}} = \ln\left(x + \sqrt{x^2 + a^2}\right) \qquad \int \frac{dx}{x^2 + a^2} = \frac{1}{a}\arctan\frac{x}{a} \qquad \int \frac{dx}{(x^2 + a^2)^{3/2}} = \frac{1}{a^2}\frac{x}{\sqrt{x^2 + a^2}}$$

$$\int \frac{x\,dx}{(x^2 + a^2)^{3/2}} = -\frac{1}{\sqrt{x^2 + a^2}}$$

# Physics 161-001 Spring 2012 Final Exam

**Name: ________________________________ Box#____________**

**1) A heat conducting rod, 1.6 m long, is made of an aluminum section that is 0.8 m long and a copper section that is 0.8 m long. Both sections have cross-sectional areas of 0.00040 $m^2$. The aluminum end and the copper end are maintained at temperatures of 20°C and 270°C, respectively. The thermal conductivity of aluminum is 205 W/m·K of copper is 385 W/m·K. The rate at which heat is conducted in the rod is closest to**

**A) 13 W**
**B) 14 W**
**C) 15 W**
**D) 16 W**
**E) 17 W**

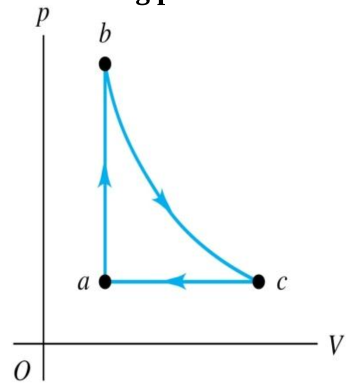
**2) 100 $cm^3$ of an ideal gas is at 27°C. It is cooled at constant pressure to -73°C. It will now occupy:**

**A) 100 $cm^3$**
**B) 37 $cm^3$**
**C) 13 $cm^3$**
**D) 67 $cm^3$**
**E) 50 $cm^3$**

**3) The pressure of an ideal gas is halved during a process in which the heat taken in by the gas equals the work done by the gas. This process is:**

**A) isobaric**
**B) isothermal**
**C) isochoric**
**D) adiabatic**
**E) impossible**

**4) An ideal gas in a chamber passes through the cycle shown below. The heat $Q_{AB}$ added during process AB is 45.0J, no heat is transferred during process BC, and the net work done in the cycle is 15.0J. Determine the net heat added to the system during process CA.**

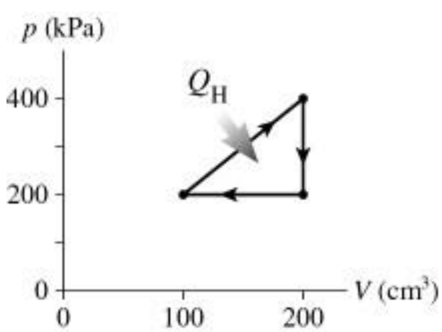



**A) 60 J**
**B) 30J**
**C) 15 J**
**D) -30J**
**E) -60J**

**5) Heat is added to some unknown gas. The amount that the average molecular kinetic energy increases depends upon:**

**A) if the volume changes.**
**B) if the pressure changes.**
**C) if the gas is monatomic or diatomic.**
**D) both A) and B)**
**E) both A) and C)**

**6) The graph in the figure shows a cycle for a heat engine for which $Q_H$ = 50 J. What is the thermal efficiency of this engine?**




**A) 29 %**
**B) 12 %**
**C) 7.4 %**
**D) 15 %**
**E) 20%**

**7) A 12 V battery is connected to a 6Ω resister which is in thermal contact with 1kg of ice. How long will it take for all the ice to melt? (The heat of fusion for ice is $3.34 \times 10^5$ J/kg)**

**A) 232 mins.**
**B) 464 mins.**
**C) 6.4 mins.**
**D) 36 mins.**
**E) 112 mins.**

**8) Rank the following pictures in terms of entropy, lowest to highest:**

**a)**  **b)**  **c)**  **d)** 

**A) a, b, c, d**
**B) b, c & d, a**
**C) a, c & d, b**
**D) c & d, a, b**
**E) b, d, c, a**

**9) If the potential in a region is given by $V(x,y,z) = 3xy-3x^2$ (with appropriate units), then the y-component of the electric field at the point (x=4m, y=2m, z=1m) is:**

**A) -12 V/m**
**B) -6 V/m**
**C) 0 V/m**
**D) +6 V/m**
**E) +12 V/m**

**10) The equipotential surfaces associated with a horizontal infinite line of charge are**

**A) radially outward from the line of charge**
**B) vertical planes**
**C) horizontal planes**
**D) concentric spheres centered on the line of charge**
**E) concentric cylinders with the line of charge on the axis**

**11) A circular parallel plate capacitor has plate area $0.01 m^2$ and separation distance between the plates of 1mm. It is charged with 4μC. What is the electric flux through a circle of radius 17.8cm between the plates and centered on the axis of the capacitor?**

**A) $4.5 \times 10^5$ Vm**
**B) $1.5 \times 10^4$ Vm**
**C) $4.5 \times 10^4$ Vm**
**D) 0 Vm**
**E) 4.0 Vm**

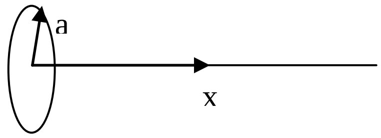
**12) Two point charges of +60.0 μC and -12.0 μC are separated by a distance of 20.0 cm. What is the magnitude of electric field due to these charges at a point midway between them? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N · $m^2/C^2$)**

**A) $64.7 \times 10^5$ N/C directed toward the negative charge**
**B) $64.7 \times 10^6$ N/C directed toward the negative charge**
**C) $64.7 \times 10^6$ N/C directed toward the positive charge**
**D) $64.7 \times 10^5$ N/C directed toward the positive charge**
**E) $64.7 \times 10^4$ N/C directed toward the negative charge**

**13) Consider the following two statements: a) Electric field lines can cross, and b) Electric field lines can curl back on themselves. Classify these statements as true or false.**

**A) a) TRUE, b) TRUE**
**B) a) TRUE, b) FALSE**
**C) a) FALSE, b) TRUE**
**D) a) FALSE, b) FALSE**

**14) Which integral would one employ to find the electric field of a ring of charge of radius a at a distance x along its axis away from its center?**




**A)** $\int \frac{dx}{\left(x^2+a^2\right)^{3/2}}$

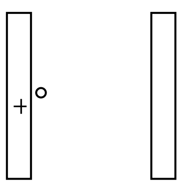
**B)** $\int \cos\theta d\theta$

**C)** $\int \frac{xdx}{\left(x^2+a^2\right)^{3/2}}$

**D)** $\int a d\theta$

**E)** $\int \frac{dx}{\left(x^2+a^2\right)^{1/2}}$

**15) A parallel plate capacitor has plate area 0.002m$^2$ and separation distance between the plates of 0.001m. It is charged with 2μC. If a 4μC charge is released from rest near the surface of the positive plate, what is its kinetic energy when it arrives at the negative plate?**




**A) 2.2 x 10$^{-4}$ J**
**B) 9.0 x 10$^{-4}$ J**
**C) It depends upon the mass of the charge.**
**D) It depends upon the potential of the positive plate.**
**E) Both C) and D)**

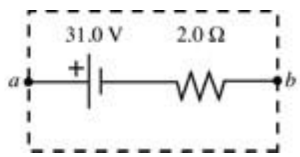
**16) An infinitely long nonconducting cylinder of radius = 2.00 cm carries a uniform volume charge density of 18.0 μC/ $m^3$. Calculate the electric field at distance = 1.00 cm from the axis of the cylinder. ( $\varepsilon_0 = 8.85\times10^{-12}$ $C^2/N \cdot m^2$)**

**A) $20.4 \times 10^3$ N/C**
**B) $10.2 \times 10^3$ N/C**
**C) $40.8 \times 10^3$ N/C**
**D) $20.4 \times 10^1$ N/C**
**E) $30.3 \times 10^4$ N/C**

**17) Suppose you have two point charges of same sign. As you move them farther and farther apart, the potential energy of this system**

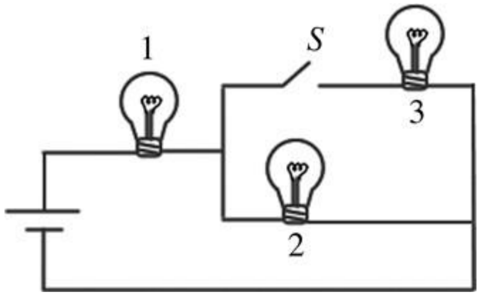
**A) increases.**
**B) decreases.**
**C) stays the same.**

**18) The emf and the internal resistance of a battery are as shown in the figure. When the terminal voltage Vab is equal to 19.0 V, what is the current through the battery?**




**A) 12.0 A**
**B) 9.5 A**
**C) 24.0 A**
**D) 6.0 A**
**E) 4.0 A**

**19) The figure shows three identical light bulbs connected to a battery having a constant voltage across its terminals. What happens to the brightness of light bulb 1 when the switch S is closed?**

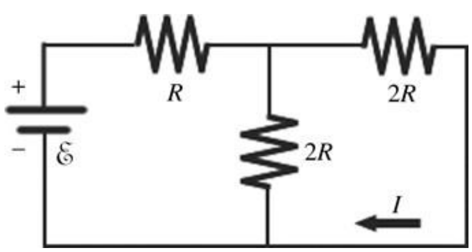



**A) The brightness remains the same as before the switch is closed.**
**B) The brightness increases permanently.**
**C) The brightness will decrease momentarily then return to its previous level.**
**D) The brightness will increase momentarily then return to its previous level.**
**E) The brightness decreases permanently.**

**20) An electron moving in the negative x direction enters a magnetic field. If the electron experiences a magnetic deflection in the negative y direction, the direction of the magnetic field in this region points in the direction of the**

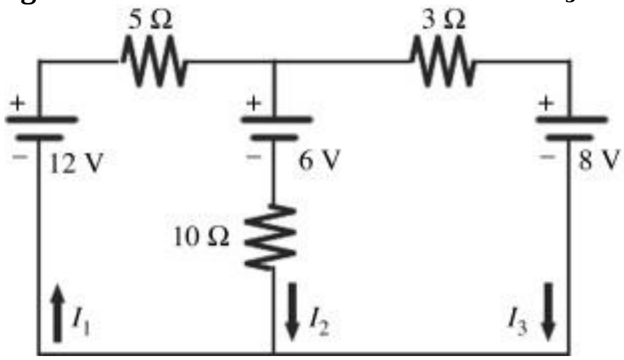
**A) -z axis.**
**B) +x axis.**
**C) +z axis.**
**D) -y axis.**
**E) -x axis.**

**21) For the circuit shown in the figure, I = 1.20 A and R = 10 Ω. What is the value of the emf $\mathcal{E}$ ?**




**A) 12 V**
**B) 48 V**
**C) 60 V**
**D) 24 V**
**E) 36 V**

**22) For the circuit shown in the figure, all quantities are accurate to 2 significant figures. What is the value of the current $I_3$?**

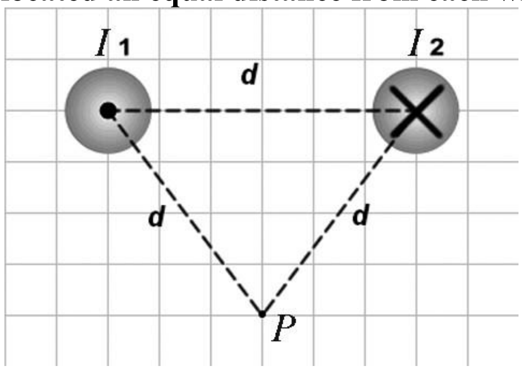



**A) 0.89 A**
**B) -0.61 A**
**C) -0.89 A**
**D) 0.32 A**
**E) 0.61 A**

**23) A 4.0-µF capacitor that is initially uncharged is connected in series with a 4.0-kΩ resistor and an ideal 17.0 V battery. How much energy is stored in the capacitor 16 ms after the battery has been connected?**

**A) $3.6 \times 10^{-4}$J**
**B) $2.3 \times 10^{-3}$J**
**C) $1.2 \times 10^{-3}$J**
**D) $2.3 \times 10^{-4}$J**
**E) $3.6 \times 10^{-4}$J**

**24) The figure shows two long, parallel current-carrying wires. The wires carry equal currents $I_1 = I_2 = 15$ A in the directions indicated and are located a distance d = 0.2 m apart. Calculate the magnitude of the magnetic field at the point that is located an equal distance from each wire. ($\mu_0 = 4\pi \times 10^{-7}$ T · m/A)**




**A) $4.2 \times 10^{-5}$ T**
**B) $2.2 \times 10^{-5}$ T**
**C) $3.0 \times 10^{-5}$ T**
**D) $1.5 \times 10^{-5}$ T**
**E) $6.3 \times 10^{-5}$ T**

**25) A large number of very long wires of diameter 1mm are laid side-by-side to form a plane. If 10.5 A of current is passed through each wire (in the same direction), what is the magnitude of the magnetic field 10cm above (and in the middle of) the plane?**

**A) $6.6 \times 10^{-3}$ T**
**B) $2.1 \times 10^{-5}$ T**
**C) $4.2 \times 10^{-5}$ T**
**D) $2.1 \times 10^{-2}$ T**
**E) $4.2 \times 10^{-3}$ T**

# Have a great summer!