Phys 172 Final Exam

Time limit: 120 minutes

Each question worths 10 points.

Show your steps. No points will be given for solutions I cannot understand.

Constants: $e = 1.6 \times 10^{-19}C$, $\epsilon_0 = 8.85 \times 10^{-12}C^2N^{-1}m^{-2}$, $\mu_0 = 4\pi \times 10^{-7}Tm/A$, mass of proton $m_p = 1.67 \times 10^{-27}kg$, mass of electron $m_e = 9.11 \times 10^{-31}kg$.

Constants: $k = 1.38 \times 10^{-23}J/K$, $R = 8.31Jmol^{-1}K^{-1}$, $N_A = 6 \times 10^{23}$, $1atm = 10^5Pa$, $1cal = 4.186J$.

Specific heat of water: $c_{solid} = 2.1kJkg^{-1}K^{-1}$, $c_{liquid} = 4.186kJkg^{-1}K^{-1}$, $c_{gas} = 2.0kJkg^{-1}K^{-1}$.

Specific heat of other materials: $c_{glass} = 0.84kJkg^{-1}K^{-1}$, $c_{gold} = 0.13kJkg^{-1}K^{-1}$, $c_{lead} = 0.13kJkg^{-1}K^{-1}$, $c_{mercury} = 0.14kJkg^{-1}K^{-1}$, $c_{aluminum} = 0.9kJkg^{-1}K^{-1}$, $c_{copper} = 0.387kJkg^{-1}K^{-1}$.

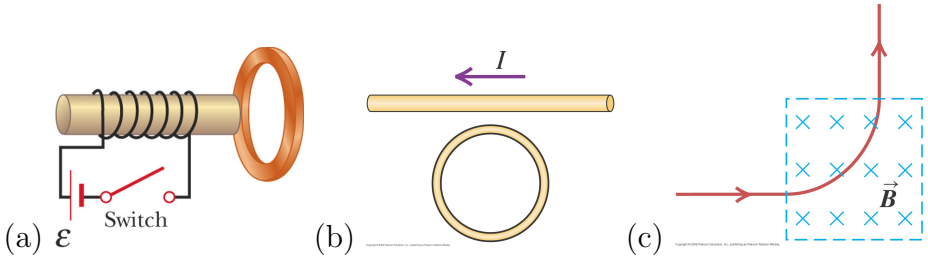
Latent Heat of water: $L_f = 333.7kJ/kg$, $L_v = 2259kJ/kg$.

Latent Heat of mercury: $L_f = 11.8kJ/kg$, $L_v = 296kJ/kg$.

Resistivity : Aluminum $2.65 \times 10^{-8}\Omega m$, Copper $1.68 \times 10^{-8}\Omega m$, Silver $1.59 \times 10^{-8}\Omega m$, Iron $9.71 \times 10^{-8}\Omega m$.

1. (a) If the switch is suddenly closed in the circuit in Figure 1a, which way (clockwise or counterclockwise) will the induced current flow on the loop if you are observing from the left hand side? (b) If the current in Figure 1b is decreasing, which way (clockwise or counterclockwise) will the induced current flow on the loop? (c) Is the charge in Figure 1c positive or negative?

Figure 1: Question 1

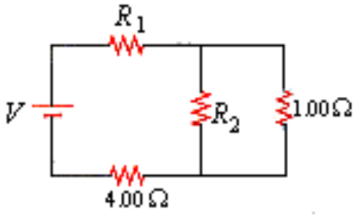


2. Figure 2 shows two pairs of wires with current going into/out of the paper. Draw the magnetic field lines, the magnetic field and the magnetic force on the wires for both case (a) and case (b). (c) [Unrelated to previous parts] What current is required in the windings of a long solenoid that has 900 turns uniformly distributed over a length of $0.4m$ to produce at the center of the solenoid a magnetic field of magnitude $1.00 \times 10^{-4}T$?

Figure 2: Question 2

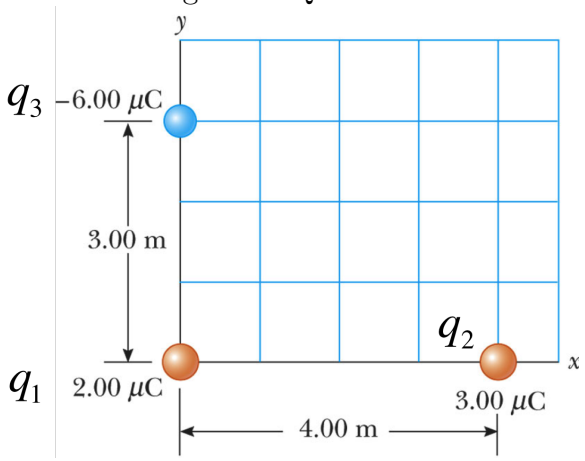
3. The two parts in this problem are unrelated. (a) Given $R_1 = 4.00\Omega$, $R_2 = 2.00\Omega$, and $V = 15.0V$ in Figure 3. Calculate the current I_1 and I_2 through the resistors R_1 and R_2. (b) Consider a circuit with a battery ($\mathcal{E} = 10V$), a resistor ($R = 2M\Omega$) and a capacitor ($C = 3\mu F$) connected in series with a switch. (i) What is the time constant of the circuit? (ii) What is the maximum amount of charge on the capacitor after the switch is closed? (iii) Find the amount of charge in the capacitor $3s$ after the switch is closed.

Figure 3: Question 3(a)



4. Figure 4 shows three charges $q_1 = 2\mu C$, $q_2 = 3\mu C$ and $q_3 = -6\mu C$. (a) Find the total potential energy of the system. (b) Find the potential at the location of q_3 created by the other two charges. (c) What is the work done by the electric field if q_3 is moved from its current location to infinity?

Figure 4: Question 4



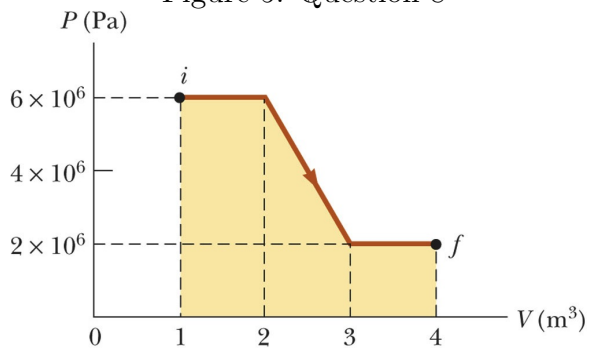
5. Two charged particles are located on the x axis. A negative charge $q_1 = -9.00\mu C$ is at $x = -2m$, and a positive charge $q_2 = +5.00\mu C$ is at $x = 1.5m$. (a) Determine the electric field vector $\vec{E}_1$, $\vec{E}_2$ and $\vec{E}_{total}$ on the y axis at $y = 0.400m$. (b) Calculate the electric force vector on a $q_3 = -3.00\mu C$ charge placed on the y axis at $y = 0.400m$.

6. (a) State the First Law and the Second Law of Thermodynamics. The First Law should be stated as an equation. (b) A combination of $0.250kg$ of water at $20.0°C$, $0.400kg$ of aluminum at $26.0°C$, and $0.200kg$ of copper at $100°C$ is mixed in an insulated container and allowed to come to thermal equilibrium. Ignore any energy transfer to or from the container and determine the final temperature of the mixture. Do not just quote the final formula without showing your steps otherwise no points will be given.

7. An ice tray contains $500g$ of liquid water at $20°C$. Be careful with the sign when you perform the calculations below. (a) Calculate the change in entropy of the water as it cools and freezes slowly and completely at $0°C$. (b) Find the heat Q for the same process.

8. Figure 5 shows a monatomic gas expanding from i to f. (a) Determine the work done by the gas during the expansion. (b) What is the energy of the gas at i and at f (i.e., find U_i and U_f)? (c) Use the first law to find the heat Q going into the system in this process.

Figure 5: Question 8



9. (a) How many atoms (give the actual number of atoms, not the number of moles) of helium gas fill a balloon having a diameter of $30cm$ at $25.0°C$ and $1.00atm$? (b) A cylinder starts out with a volume of $15 \times 10^{-4} m^3$ at a temperature of $30°C$. Assuming an isobaric process, calculate the new volume when the temperature is changed to $-100°C$. (c) The temperature at the surface of the Sun is approximately at $5700K$, and the temperature at the surface of the Earth is approximately $290K$. What entropy change occurs when $1000J$ of energy is transferred by radiation from the Sun to the Earth?

10. (a) Does two beams of light always combine to produce a stronger beam of light? Explain in a few sentences. (b) Speedo and Goslo are twins. Speedo got on a rocket and make a round trip to a planet and back to Earth at close to the speed of light. When they meet again, are they still the same age? If not, who is older? Explain in a few sentences.