Phys 1402: General Physics II **Name:** Key

Fall 2014 **Exam 1 – Version A**

- Please tear off the Equation Sheet.
- For Multiple Choice questions, circle the letter of your choice.
- For Short Answer questions, put your answer in the blank provided, with units. In the larger blank areas, show your thinking. This gives you the maximum chance for partial credit.

1. A helium nucleus ($q = +3.2 \times 10^{-19}$ C and $m = 6.64 \times 10^{-27}$ kg) and an electron are near each other. What is the direction of the forces they exert on each other?
   a. The helium nucleus is attracted toward the electron, but the electron is repelled because it is negative.
   b. The helium nucleus is repelled from the electron, but the electron is attracted because it is negative.
   c. They are attracted toward each other.
   d. They are repelled from each other.
   e. The force is perpendicular to the imaginary line connecting the particles.

   Opposites Attract

2. A helium nucleus ($q = +3.2 \times 10^{-19}$ C and $m = 6.64 \times 10^{-27}$ kg) and an electron are near each other. Which feels the greater force? (Compare the magnitudes of the forces. Assume the electrostatic force is the only force they experience.)
   a. The forces are the same strength.
   b. The electron feels a stronger force because it is less massive.
   c. The electron feels a stronger force because it has less charge.
   d. The helium nucleus feels a stronger force because it is more massive.
   e. The helium nucleus feels a stronger force because it has more charge.

   $F = \frac{k q_0 q_1}{r^2}$ Swap q_0 and q_1, and the result is the same.

3. A helium nucleus ($q = +3.2 \times 10^{-19}$ C and $m = 6.64 \times 10^{-27}$ kg) and an electron are near each other. Which has a greater acceleration? (Compare the magnitudes of the accelerations. Assume the electrostatic force is the only force they experience.)
   a. The electron accelerates more rapidly because it is less massive.
   b. The electron accelerates more rapidly because it has less charge.
   c. The helium nucleus accelerates more rapidly because it is more massive.
   d. The helium nucleus accelerates more rapidly because it has more charge.
   e. The accelerations are the same.

   $a = \frac{F}{m}$ Smaller mass → bigger accel.

4. A balloon that is rubbed against a cotton or wool shirt becomes negatively charged. This ballon can be weakly stuck to a wall. Why does the balloon stick to the wall?
   a. The wall is negatively charged.
   b. The wall is positively charged.
   c. The wall is made entirely of neutral particles, which are attracted to charges.
   d. The wall is charged by the balloon, so that there are more attracted charges than repelled charges.
   e. The wall's charges are shifted by the balloon, so that the attracted charges are closer and make a stronger force.

5. A large positive charge (many microcoulombs) $+Q$ is located at the origin. As an electron $-e$ is brought nearby, what happens to the electric potential and electric potential energy experienced by the tiny charge? (Note: a change from -2 to -3 is considered a decrease.)
   a. The electric potential increases while the electric potential energy increases.
   b. The electric potential increases while the electric potential energy decreases.
   c. The electric potential decreases while the electric potential energy increases.
   d. The electric potential decreases while the electric potential energy decreases.

   $V = \frac{k q_1}{r}$ increases

   Energy $= q_0 V$ decreases when q_0 is ⊖

6. A 0.5 F capacitor is charged up to a potential difference of 10 V. What is the total charge of the capacitor, including both plates?
   a. 0.5 C
   b. 2.0 C
   c. 0.05 C
   d. 0.0 C
   e. −0.5 C

   $Q = CV = (0.5F)(10v) = 5C$ is the charge on one plate. The other has $Q = -5C$.

7. How many electrons does it take to form a coulomb of charge?
   a. 6.25×10^{18} electrons
   b. 1.6×10^{-19} electrons
   c. 9.1×10^{-31} electrons
   d. 1.6×10^{18} electrons
   e. 1.1×10^{30} electrons

   $\frac{1C}{1.6\times10^{-19}C} = 6.25\times10^{18}$

8. In a working electrical circuit, the electric current has this behavior:
   a. It is emitted by the battery and absorbed by the load.
   b. It is emitted by the load and absorbed by the battery.
   c. It flows in the air around the wires, in a direction determined by the right-hand rule.
   d. It circulates around the circuit like blood flowing around our cardiovascular system.
   (Note: The "load" is the device using the electricity, such as a light bulb, motor, or resistor.)

9. When a resistor in a circuit has electrons flowing toward the left, what is the direction of the electric current in the resistor?
   a. Clockwise
   b. Counter-clockwise
   c. Leftward
   d. Rightward
   e. Outward, away from the resistor.

   Opposite

10. If a circuit consists of a battery, an appropriate light bulb, and an ideal ammeter, all in parallel,
    a. The bulb will be lit, but the ammeter will display zero.
    b. The bulb will be lit, and the ammeter will display the bulb's normal operating current.
    c. The bulb will be off, and the ammeter will display zero.
    d. The bulb will be off, and the ammeter will display the bulb's normal operating current.
    e. The bulb will be off, and the ammeter will measure an enormous current.

    is a short circuit.

11. A cylindrical wire has a radius r and a length ℓ. If ℓ is doubled while r is cut in half, the resistance of the wire…
    a. Increases.
    b. Decreases.
    c. Remains the same.
    d. It depends on which of r and ℓ is larger.

    $R = \rho\frac{\ell}{A} = \rho\frac{2\ell_0}{(1/4)A_0} = 8R_0$

12. A 14 Ω resistor is connected to a 7.0 V adjustable power supply. If the voltage is doubled, what happens to the resistance?
    a. The resistance increases 4×.
    b. The resistance doubles.
    c. The resistance stays the same.
    d. The resistance is cut in half.
    e. The resistance decreases 4×.

    The resistor was not changed.

13. Two 50 Ω resistors are placed in **series** and each has 0.3 A flowing through it. Fill in the table:

$V = IR$

	V	*I*	*R*	*P*
Each Resistor	15 V	0.3 A	50 Ω	4.5 W
Overall Circuit	30 V	0.3 A	100 Ω	9.0 W

$P = IV$

V adds ↗ Same I ↗ $R = \frac{V}{I}$

14. Two 50 Ω resistors are placed in **parallel** and each has 0.3 A flowing through it. Fill in the table:

	V	*I*	*R*	*P*
Each Resistor	15 V	0.3 A	50 Ω	4.5 W
Overall Circuit	15 V	0.6 A	25 Ω	9.0 W

$P = IV$

Same V ↗ I adds ↗ $R = \frac{V}{I}$

15. In a simplified version of the Millikan oil-drop experiment, tiny droplets of oil have single electrons removed from them. An electric field between two plates is adjusted so that the droplets have zero acceleration. If an oil droplet has a mass of 3.27×10^{-16} kg, what is the strength of the electric field? (Hint: What is the charge if exactly one electron is removed?)

Answer: 20000 N/C

$F_E = F_g$

$qE = mg$

$E = \frac{mg}{q} = \frac{(3.27 \times 10^{-16}\ kg)(9.8\ N/kg)}{1.6 \times 10^{-19}\ C}$

16. If a CFL bulb uses 15 W, and electricity costs \$0.12/kWh, calculate how much money is spent in 720 hours (i.e. 1 month) of continuous operation.

Answer: \$1.30

$\text{Energy} = P\Delta t = (0.015\ kW)(720\ h) = 10.8\ kWh$

$\text{Cost} = \$1.30 = (10.8\ kWh)\left(\frac{\$0.12}{kWh}\right)$

17. What length of copper wire is needed to make a 0.10 Ω resistor, if the wire has an area of $5.0 \times 10^{-6}\ m^2$? (The resistivity of copper is about $1.72 \times 10^{-8}\ \Omega \cdot m$.)

Answer: 29.1 m

$R = \rho \frac{\ell}{A}$

$\ell = \frac{RA}{\rho} = \frac{(0.1\ \Omega)(5 \times 10^{-6}\ m^2)}{(1.72 \times 10^{-8}\ \Omega\ m)}$

18. A 12 V battery is connected in a circuit with a 4 Ω resistor and a 0.5 F capacitor. The capacitor is initially empty. What is the time constant of the circuit?

Answer: 2.0 s

$\tau = RC = (4\Omega)(0.5F)$

19. A 12 V battery is connected in a circuit with a 4 Ω resistor and a 0.5 F capacitor. The capacitor is initially empty. How much current is flowing after two time constants (i.e. when $t = 2\tau$)? (Hint: How much current is flowing initially?)

Answer: 0.406 A

$I_0 = \frac{V_0}{R} = \frac{12V}{4\Omega} = 3A$

$I = I_0 e^{-t/\tau} = (3A)e^{-2}$

20. The bottom of a thundercloud is 2400 m above Earth's surface. The cloud has an area of 12 km^2. Assume that the cloud and the part of Earth's surface underneath it form a perfect capacitor. What is the capacitance of the thundercloud-Earth system? (Assume the dielectric constant is equal to one.)

Answer: 4.43×10^{-8} F

$C = \frac{\varepsilon_0 A}{d} = \frac{8.85\times10^{-12}(C^2/Nm^2)(12\times10^6 m^2)}{2400 m}$

21. The bottom of a thundercloud is 2400 m above Earth's surface. The cloud has an area of 12 km^2. If the air can support an electric field of 10^6 N/C, how much voltage can exist between the thundercloud above and Earth's surface?

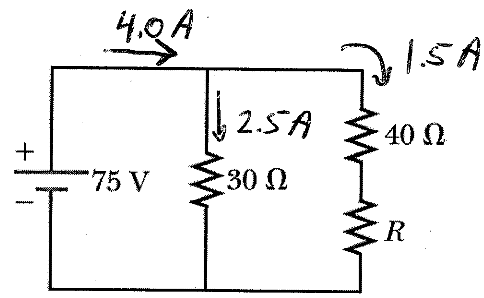
Answer: 2.4×10^9 V

$\Delta V = E \cdot d = (10^6 \frac{V}{m})(2400 m)$

Name: Key

Exam 1 – Version A

Consider the following circuit:



The current flowing through the battery is 4.0 A. **Fill in the missing values** in the table below.

Component	Voltage Across	Current Through	Resistance
30 Ω	75.0 V	2.5 A	30.0 Ω
40 Ω	60.0 V	1.5 A	40.0 Ω
R	15.0 V	1.5 A	10 Ω
Battery	75.0 V	4.0 A	n/a

- $V_{30} = 75.0\ V$
- $I_{30} = \frac{75\ V}{30\ \Omega} = 2.5\ A$
- $I_{40} = 4.0\ A - 2.5\ A = 1.5\ A = I_R$
- $V_{40} = (1.5\ A)(40\ \Omega) = 60\ V$
- $V_R = (75\ V) - (60\ V) = 15\ V$
- $R = \frac{15\ V}{1.5\ A} = 10\ \Omega$