PHYS 223 University Physics III

GRADES
100
95
91
79

Exam 3
February 22, 2023

Name ____J. C. Daly____

a. What is the capacitance seen by the 12 V battery in Figure 1? ____5 μF____

b. What is the energy stored in the 4uF capacitor? ____72 μJ____

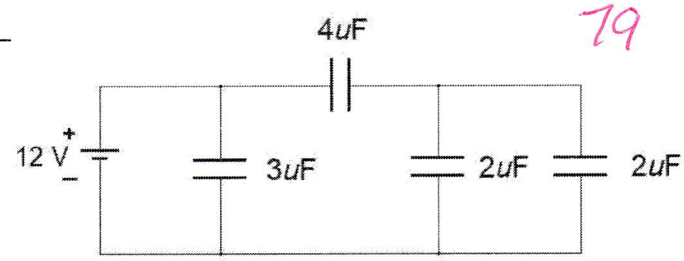


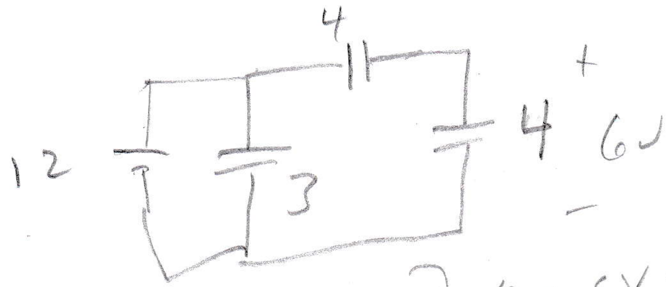
Figure 1

$W = \frac{1}{2} C V^2$

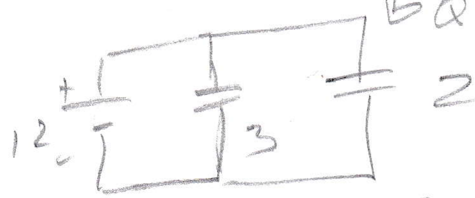
$= \frac{1}{2} 4 \times 10^{-6} \times 36$

72×10^{-6} Joules

$C_{eq} = 5 \mu F$



$Q = CV = 24$



$W = \frac{1}{2} \frac{Q^2}{C}$

$= \frac{1}{2} \frac{(24)^2}{4}$

$= \frac{24}{8} \times 24$

$3 \times 24 = 72$

6 Volts appears across the 4 μF Capacitor

$W = \frac{1}{2} C V^2 = \frac{1}{2} \times 4 \times 36 \times 10^{-6}$

$W = 72 \mu J$

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2. A 120 V potential is applied to a space heater whose resistance is 10 ohms when hot.

   a. What is the power dissipated in the heater? 1.44 kW

   b. What is the cost for 2 h at US$0.15/kW*h? 43.2¢

$$P = I^2 R = \frac{V^2}{R} = \frac{(120)^2}{10} = \frac{14400}{10}$$

a) $P = 1.44\ kW$

$$kW \cdot h = P \cdot h = 1.44 \times 10^3 \times 2$$
$$= 2.88\ kW \cdot h$$

b) $2.88\ kW \cdot h * 0.15\ \$/kW \cdot h$
$$= 43.2¢$$

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3. A certain parallel-plate capacitor is filled with a dielectric for which $k = 5..0$. The area of each plate is 0.025 m^2, and the plates are separated by 2.0 mm.. The capacitor will fail (short out and burn up) if the electric field between the plates exceeds 150 kN/C. What is the maximum energy that can be stored in the capacitor?

$$E = \frac{V}{d}$$

$$V_{Max} = E_{max} d = 150 \times 10^{3} \times 2 \times 10^{-3}$$

$$V_{Max} = 300 \text{ Volts}$$

$$W = \text{Energy} = \frac{1}{2} C V^2 = \frac{1}{2} \frac{K\epsilon_0 A}{d} \cdot 300^2$$

$$C = K C_0$$

$$= \frac{1}{2} \frac{5.0 * 8.854 \times 10^{-12} * 0.025 \times (300)^2}{2 \times 10^{-3}}$$

$$W = \frac{25 * 8.854 \times 0.025 * 9 \times 10^{4-12+3}}{2}$$

$$C = \frac{5 \times 8.854 \times 10^{-12} \times .025}{2 \times 10^{-3}} = 5.5 \times 10^{-10} F$$

$$W = 24.9 \times 10^{-6} J$$

$$\boxed{W_{Max} = 25 \mu J}$$

Physical Constants

Constant	Symbol	Magnitude
Avogadro's Number	N_A	6.022×10^{23} molecules/mole
Boltzmann's constant	k	1.38×10^{-23} J/K = 8.62×10^{-5} eV/K
Stefan-Boltzmann constant	σ	5.67×10^{-8} J/(s*m^2*K^4)
Electronic charge	q	1.6×10^{-19} C
Electronvolt	eV	1.6×10^{-19} J
Planks constant	h	6.625×10^{-34} J-s
Thermal voltage, kT, at 300 ^oK	V_t	25.8 mV
Velocity of light	c	3×10^8 m/s
Permeability of free space	u_o	1.257×10^{-6} H/m
Permittivity of free space	ε_o	8.854×10^{-12} F/m
Electron mass	m_e	9.1×10^{-31} kg
Proton mass	m_p	1.673×10^{-27} kg

Atomic Masses

Element	Symbol	Atomic Mass	Atomic Number
Hydrogen	H	1.00794 u	1
Helium	He	4.00260 u	2
Lithium	Li	6.941 u	3
Beryllium	Be	9.0122 u	4
Boron	B	10.811 u	5
Carbon	C	12.0107 u	6
Nitrogen	N	14.0067 u	7
Oxygen	O	15.9994 u	8
Fluorine	F	18.9984 u	9
Neon	N	20.1797 u	10
Sodium	Na	22.9897 u	11
Magnesium	Mg	24.305 u	12
Aluminum	Al	26.9815 u	13
Silicon	Si	28.0855 u	14
Phosphorus	P	30.9738 u	15