Physics 10154 - Exam #5a

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work (or if some parts are incorrect) even if you get the right answer. Clearly indicate your answer with a circle or box and remember to include correct units and significant figures.

1. (25 pts) Some amount of Oxygen gas is in a piston chamber with a pressure of 2.5 atm and a temperature of 35°C. The density of the gas is measured to be 0.54 kg/m^3. If the pressure is reduced to 1.5 atm and the temperature increased to 95°C, what is the new density of the gas? Assume the number of moles of gas doesn't change but the volume may change.

$$\frac{V_2}{V_1} = \frac{\left(\frac{n_2}{n_1}\right)\left(\frac{R}{R}\right)\left(\frac{T_2}{T_1}\right)}{\left(\frac{P_2}{P_1}\right)} = \frac{(1)(1)\left(\frac{368K}{308K}\right)}{\left(\frac{1.5}{2.5}\right)} = 1.99$$

$$\frac{\rho_2}{\rho_1} = \frac{\left(\frac{M_2}{M_1}\right)}{\left(\frac{V_2}{V_1}\right)} = \frac{1}{1.99}$$

$$\rho_2 = \left(\frac{1}{1.99}\right)(0.54) = 0.27\ kg/m^3$$

2. (25 pts) A 1.5 kg glass beaker contains 280 grams of water, both at a temperature of 25°C. A 720 gram beryllium block with an initial temperature of 1600°C is added to this system. Assuming the water all turns to steam and everything reaches the same final equilibrium temperature (glass, copper and water), what is the final temperature of the system?

The specific heat of glass is 837 J/kg °C.
The specific heat of beryllium is 1820 J/kg °C.
The specific heat of water is 4186 J/kg °C.
The specific heat of steam is 2010 J/kg °C.
The latent heat of vaporization for water is 2,260,000 J/kg.

$$\Delta Q_{water} = (0.280)(4186)(100-25) + (0.280)(2.26\times10^6) + (0.280)(2010)(T_F - 100)$$

$$= 87906 + 632800 + 562.8\,T_F - 56280$$

$$= 664426 + 562.8\,T_F$$

$$\Delta Q_{glass} = (1.5)(837)(T_F - 25)$$

$$= 1255.5\,T_F - 31387.5$$

$$\Delta Q_{Be} = (.720)(1820)(T_F - 1600)$$

$$= 1310.4\,T_F - 2096640$$

$$\Delta Q_w + \Delta Q_g + \Delta Q_{Be} = 0$$

$$3128.7\,T_F - 1463601.5 = 0$$

$$\boxed{T_F = 470^\circ C}$$

3. (25 pts) Gas goes through a cycle A --> B --> C --> A

State A: P = 2.0 atm, V = 3.0 L — 202600 Pa, $3 \times 10^{-3}\ m^3$
State B: P = 9.0 atm, V = 3.0 L — 911700 Pa, $3 \times 10^{-3}\ m^3$
State C: P = 6.0 atm, V = 15 L — 607800 Pa, $15 \times 10^{-3}\ m^3$

During this cycle, how much heat must be added to the gas?

$$W_{by\ gas}(A \to B) = 0 \quad (\Delta V = 0)$$

$$W_{by\ gas}(B \to C) = \left(\frac{911700 + 607800}{2}\right)(12 \times 10^{-3})$$

$$= 9117\ J$$

$$W_{by\ gas}(C \to A) = \left(\frac{607800 + 202600}{2}\right)(-12 \times 10^{-3})$$

$$= -4862\ J$$

$$W_{by\ gas}(cycle) = 4255\ J$$

$$\Delta U(cycle) = 0$$

$$\Delta U = Q - W_{by\ gas}$$

$$0 = Q - 4255$$

$$\boxed{Q = 4300\ J}$$

4. (25 pts) A 620 gram mass is attached to a horizontal spring on a frictionless surface. The spring constant is 44 N/m. The spring is compressed by 32 cm and released from rest.

a) What is the total mechanical energy of this system?

b) After the mass has moved 16 cm from its original position, what is its speed?

c) What is the maximum speed of the mass as it oscillates back and forth?

a) $E = \frac{1}{2}kA^2 = \frac{1}{2}(44)(.32)^2 = 2.25$

2.3 J

b) $v = \sqrt{\frac{k}{m}(A^2 - x^2)}$

$= \sqrt{\frac{44}{.62}(.32^2 - .16^2)} = \sqrt{5.45} = 2.3\ m/s$

c) $v = \sqrt{\frac{k}{m}A^2} = \sqrt{\frac{44}{.62}(.32)^2} = \sqrt{7.27} = 2.7\ m/s$

check $\frac{1}{2}(.620)(2.7)^2 = 2.3\ J$ ✓