Name______________________________Pd________

Internal Energy—It's A Gas!

$$Q_{in} = W_{out} + \Delta U$$
$$U = {}^{3}/_{2}nRT$$

1. 2500 J of heat energy is supplied to a gas in a closed container. If the closed container has a piston at one end, and in moving the piston the gas does 1725 J of work on the piston, what is the change in internal energy of the gas? Did the gas gain that energy, or lose that energy?

We'll use $Q_{in}=W_{out}+\Delta U$ $2500 = 1725 + \Delta U$

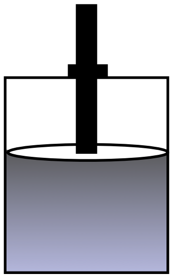
$\Delta U = 775$ J
The gas gained that energy, as its temperature increased

2. What is the internal energy of 34 moles of an ideal gas in a closed container if the temperature is kept at a constant 35°C?

Normalizing units: $35^\circ C = 308$ K
We'll use $U=3/2nRT$ $U = 3/2(34)(8.314)(308)$
$U = 1.31\cdot10^{5}$ J

3. The internal energy of an ideal gas at 345 K is 325 J. If there 12 m^3 of the gas present, what pressure would a gauge connected to the container read?

First we'll use $U=3/2nRT \rightarrow n = 2U/3RT = 2(325)/(3)(8.314)(345) = 0.07554$ mol
Second we'll use $PV=nRT \rightarrow P = nRT/V = (.07554)(8.314)(345)/12$
$P = 18.1$ Pa



4. As shown at right, an ideal gas is contained in a cylinder with a movable piston at one end. If the piston is quickly pushed toward the gas, thereby compressing it, what will be the change in internal energy of the gas if the piston is pushed with a force of 500 N through a distance of 0.2 m, and no heat is allowed to enter or leave the cylinder?

Remembering: $Work=F\cdot d$ and work input is negative
We'll use $Q_{in}=W_{out}+\Delta U$ $0 = -(500)(.2) + \Delta U$
$\Delta U = 100$ J

5. A weather balloon at ground level holds 22.4 liters of an ideal gas. If the gas inside the balloon is at a pressure of 3200 kPa, and the air temperature is 55˚F, a) how many moles of gas are in the balloon, and b) what is the original internal energy of the gas?

Normalizing units: $55^\circ F = 12.8^\circ C = 285.8$ K
First we'll use $PV=nRT \rightarrow n = PV/RT = (32\cdot10^{5})(.0224)/(8.314)(285.8) = 30.17$ mol
Second we'll use $U=3/2nRT = 3/2(30.17)(8.314)(285.8) = 1.08\cdot10^{5}$ Pa

6. If the balloon in the previous problem was set aloft to a place in the atmosphere where the pressure was ⅘ of the "ground level" pressure, but the volume of the balloon remained unchanged (due to its construction), and 2572 J of heat energy were removed from the gas as it went up, find:
   a) the change in internal energy of the gas,
   b) the work done by the gas,
   c) the temperature change in the gas, and
   d) the number of moles of gas in the balloon

First we'll use $Q_{in}=W_{out}+\Delta U$
$\Delta U = Q_{in}$ since $W=P\Delta V=0$ So $\Delta U = -2572$ J
Second, we know $W = 0$ (since $\Delta V = 0$)
Third we'll use $\Delta U=3/2nR\Delta T \rightarrow \Delta T = 2\Delta U/3nR$
$\Delta T = 2(-2572)/(3)(30.17)(8.314) = -6.8$ K
Fourth, the number of moles stays constant at 30.17 mol

*Small calculation: Since P decreases by ⅘, T does too
so $T_2=228.6$ K
You could get ΔT = -57.2 K this way
Mr. S. made a miscalculation on the energy when setting up the initial conditions...