APS 104S, Midterm #1, Feb.7, 2007

Do all 7 questions in the examination booklet. Put a square box around your final answers.
Be sure to put your name and student number on the front of the booklet.
The test is 1 hour and 50 minutes long.
Calculator: Type 2 - Non-programmable calculators are allowed.
Programmable calculators are not allowed.
No other aids are allowed.

At 298K	**C^o_p(J/mol K)**	**ΔH^o_f(kJ/mol)**
H_2O(l)	75.3	-285.8
H_2O(g)	33.6	-241.8
C_2H_2(g)	33.0	226.7
CO_2(g)	37.1	-393.5
O_2	29.4	0

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(1) (7 marks) A tank contains 480.0 grams of oxygen and 80.00 grams of helium at a total pressure of 7.00 bar. The atomic mass of oxygen is 16.00 g/mole, and the atomic mass of helium is 4.00 g/mole.

Calculate the following.

a) How many moles of O_2 are in the tank?
b) How many moles of He are in the tank?
c) Mole fraction of O_2 .
d) Mole fraction of He.
e) Partial pressure of O_2 .
f) Partial pressure of He.

2) (4 marks) You are on a long trip in a hot air balloon, and have brought along some shampoo. However there was some gas inside the shampoo bottle when you boarded the gondola at the beginning of your journey. Being a good scientist, you make measurements throughout the trip, so you know that when you boarded the gondola, the shampoo bottle contained 435 mL of gas, under a pressure of 1.10 bar, at a temperature of 30.0°C. When you climb high into the air the bottle starts to expand, and eventually explodes covering you and your companions with shampoo. Eager to explain this phenomenon, you note that the pressure has dropped to 0.734 bar and the temperature has dropped to 5.00°C. To what new volume did the gas inside the bottle expand after it burst?

Data for questions 3 and 4 is in the table on the front page.

3) (12 marks) An electric kettle transfers heat to its contents at a rate of 1500 J/s. It is used to boil 10.0 moles of H_2O. The water is initially liquid at 25°C and 1.00 bar, and ends up as vapour at 100°C and 1.00 bar. Assuming that no heat is lost to the surroundings:

a) How long does it take for the water to reach 100°C?

b) Calculate the heat of vapourization of water at 100°C using the data on the front page of the exam.

c) How long does it take for the kettle to heat up and vapourize all the water?

d) How much work is done **on the surroundings** during the vapourization of the water.

e) What is the change in the internal energy of the water during the whole process (heating + vapourization)?

4) (8 marks) A welder uses an oxy-acetylene torch to cut through an iron tank. The combustion of acetylene is given by the following equation:

$$2\ C_2H_2\ (g) + 5\ O_2\ (g) \dashrightarrow 4\ CO_2\ (g) + 2\ H_2O\ (g)$$

a) If the welder uses the torch to heat up 1.00 kg of iron [specific heat capacity is 449 J/(kg K)] and we assume all the enthalpy of combustion is transferred to the iron, how many moles of acetylene would be required to heat up the iron by 10.0 K.

b) What is the adiabatic flame temperature for acetylene burning in pure oxygen? (The temperature of the flame if none of the enthalpy of combustion is lost to the surroundings.)

5) (6 marks) A sample consisting of 2.00 mol of perfect (ideal) gas molecules initially at p_1 = 111 kPa and T_1 = 277 K is heated reversibly to 356 K at constant volume.

Calculate the final pressure, p_2 ΔU, q and w, given that $C_{V,m} = \frac{5}{2}R$

6) (10 marks) Nitroglycerine, an explosive, has an assumed density of 1.0 g/cm3 and decomposes according to the following process:

$$4\ C_3H_5(NO_3)_{3\ (l)} \rightarrow 12\ CO_{2\ (g)} + 10\ H_2O_{\ (g)} + 6\ N_{2\ (g)} + O_{2\ (g)}$$

(a) 113.5 g of liquid nitroglycerine is confined to a diathermic (heat conducting) cylinder with a piston resting on the liquid surface. The cylinder is immersed in a constant temperature bath at 25.0°C, and the pressure in the surroundings is 1.00 bar. The nitrogylercine isothermally decomposes, resulting in the movement of the piston. Identify the system and surroundings, calculate q, w and ΔU and comment on the nature of the sign of each.

(b) Calculate the amount of maximum work (w) the system could do on the surroundings during the decomposition described in (a).

7) (3 marks) When 229 J of energy is supplied as heat to 3.0 mol of Ar(g) **at constant pressure**, the temperature of the sample increases by 2.55 K. Calculate the molar heat capacities at constant volume and constant pressure of the Ar(g), which may be treated as an ideal gas.