Homework 2 – The First Law

Name: ____________________________

Exercise 2A.4(a) (5 points)

A sample consisting of $1.00\ mol$ Ar is expanded isothermally at $20\ ^{\circ}C$ from $10.0\ dm^3$ to $30.0\ dm^3$ (i) reversibly, (ii) against a constant external pressure equal to the final pressure of the gas, and (iii) freely (against zero external pressure). For the three processes calculate q, w, and ΔU.

Exercise 2A.5(a) (5 points)

A sample consisting of $1.00\ mol$ of perfect gas atoms, for with $C_{V,m} = \frac{3}{2}R$, initially at $p_1 = 1.00\ atm$ and $T_1 = 300\ K$, is heated reversibly to $400.0\ K$ at constant volume. Calculate the final pressure, ΔU, q, and w.

Exercise 2B.3(a) (5 points)

When $3.0\ mol$ O_2 is heated at a constant pressure of $3.25\ atm$, its temperature increases from $260\ K$ to $285\ K$. Given that the molar heat capacity of O_2 at constant pressure is $29.4\frac{J}{mol\ K}$, calculate q, ΔH, and ΔU.

Exercise 2C.3(b) (10 points)

From the following data, determine $\Delta_f H^{\ominus}$ for diborane, $B_2H_6(g)$, at $298\ K$:

1	$B_2H_6(g) + 3\,O_2(g) \longrightarrow B_2O_3(s) + 3\,H_2O(g)$	$\Delta_{rxn}H^{\ominus} = -1941 {}^{kJ}/_{mol}$
2	$2\,B(s) + \frac{3}{2}\,O_2(g) \longrightarrow B_2O_3(s)$	$\Delta_{rxn}H^{\ominus} = -2368 {}^{kJ}/_{mol}$
3	$H_2(g) + \frac{1}{2}\,O_2(g) \longrightarrow H_2O(g)$	$\Delta_{rxn}H^{\ominus} = -241.8 {}^{kJ}/_{mol}$

Exercise 2D.1(a) (10 points)

Estimate the internal pressure, π_T, of water vapor at $1.00\ bar$ and $400.0\ K$, treating it as a van der Waals gas. *Hint*: Simplify the approach by estimating the molar volume by treating the gas as perfect.

Exercise 2D.4(a) (5 points)

The isothermal compressibility of water at $293\ K$ is $2.21 \times 10^{-6} atm^{-1}$. Calculate the pressure that must be applied in order to increase its density by $0.10\ \%$.

Discussion Question 2E.1 (5 points)

Why are adiabats steeper than isotherms?

Exercise 2E.3(a) (5 points)

A sample consisting of $1.0\ mol$ of perfect gas molecules with $C_V = 20.8 \frac{J}{K}$ is initially at $4.25\ atm$ and $300.0\ K$. It undergoes reversible adiabatic expansion until its pressure reaches $2.50\ atm$. Calculate the final volume and temperature and the work done.