

## Homework 2 – The First Law

Name: \_\_\_\_\_

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

A sample consisting of  $1.00 \text{ mol}$  Ar is expanded isothermally at  $20^\circ\text{C}$  from  $10.0 \text{ dm}^3$  to  $30.0 \text{ dm}^3$  (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  $\Delta U$ .

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

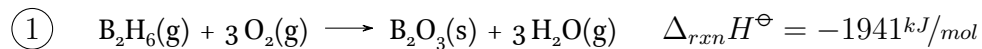
A sample consisting of  $1.00 \text{ mol}$  of perfect gas atoms, for with  $C_{V,m} = \frac{3}{2}R$ , initially at  $p_1 = 1.00 \text{ atm}$  and  $T_1 = 300 \text{ K}$ , is heated reversibly to  $400.0 \text{ K}$  at constant volume. Calculate the final pressure,  $\Delta U$ ,  $q$ , and  $w$ .

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

When  $3.0 \text{ mol}$   $\text{O}_2$  is heated at a constant pressure of  $3.25 \text{ atm}$ , its temperature increases from  $260 \text{ K}$  to  $285 \text{ K}$ . Given that the molar heat capacity of  $\text{O}_2$  at constant pressure is  $29.4 \frac{\text{J}}{\text{mol K}}$ , calculate  $q$ ,  $\Delta H$ , and  $\Delta U$ .

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

From the following data, determine  $\Delta_f H^\ominus$  for diborane,  $\text{B}_2\text{H}_6(\text{g})$ , at 298 K:

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

Estimate the internal pressure,  $\pi_T$ , 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  $2.21 \times 10^{-6} \text{ atm}^{-1}$ . 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  $\text{mol}$  of perfect gas molecules with  $C_V = 20.8 \frac{\text{J}}{\text{K}}$  is initially at 4.25  $\text{atm}$  and 300.0  $K$ . It undergoes reversible adiabatic expansion until its pressure reaches 2.50  $\text{atm}$ . Calculate the final volume and temperature and the work done.