REVIEW QUESTIONS
Chapter 18

1. Calculate the heat of reaction ($\Delta H°$) in kJ/mol for the reaction shown below, given the $\Delta H_f°$ values for each substance:

	NH_3 (g)	+	3 F_2 (g)	→	NF_3 (g)	+	3 HF (g)
$\Delta H_f°$ (kJ/mol)	–46.1		0		–125		–271

2. Given ΔH= +290.7 kJ for the reaction shown below, calculate the $\Delta H_f°$ for CO (g).

	Cr_2O_3 (s)	+	3 CO (g)	→	2 Cr (s)	+	3 CO_2 (g)
$\Delta H_f°$ (kJ/mol)	–1139.7		???		0		–393.5

3. The air within a piston equipped with a cylinder absorbs 565 J of heat and expands from an initial volume of 0.10 L to a final volume of 0.85 L against a pressure of 1.0 atm. What is the change in the internal energy of the air within the piston?

4. How much work (in J) is required to expand the volume of a pump by 2.5 L against an external pressure of 1.1 atm?

5. Calculate the work associated with the following reaction at 1.00 atm and 25°C. Is the work done by the system or on the system?

$$2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (l)$$

6. The enthalpy change for vaporization of methanol (CH_3OH) at 25°C is 38.0 kJ/mol. If the entropy of methanol vapor at 25°C is 255 J/molK, what is the entropy of the liquid methanol at this temperature?

7. A reaction has $\Delta H_{rxn} = -107$ kJ and $\Delta S_{rxn} = 285$ J/K. At what temperature is the change in entropy for the reaction equal to the change in entropy for the surroundings?

8. Determine the entropy change ($\Delta S°$) in J/K for the reaction shown below, given the standard entropies for each:

	$2\ SO_2\ (g)$	+	$O_2\ (g)$	$\rightarrow$	$2\ SO_3\ (g)$
$S°$ (J/K mol)	248.1		205.03		256.6

9. Given the following thermodynamic data, estimate the temperature (°C) at which the reaction shown below becomes spontaneous.

$$CaCO_3\ (s) \rightarrow CaO\ (s) + CO_2\ (g)$$

$\Delta H° = +184$ kJ $\quad$ $\Delta S° = +166$ J/K $\quad$ $\Delta G° = +300$ kJ

10. Calculate the free energy ($\Delta G°$) in kJ for the reaction shown below, given the $\Delta G°_f$ values for each substance:

	$4\ NH_3\ (g)$	+	$5\ O_2\ (g)$	$\rightarrow$	$4\ NO\ (g)$	+	$6\ H_2O\ (g)$
$\Delta G°_f$ (kJ/mol)	–16.48		0		86.67		–228.59

11. Methanol can be produced by the reaction shown below, with the following thermodynamic data given at 25°C.

	$CO\ (g)$ +	$2\ H_2\ (g)$ $\rightarrow$	$CH_3OH\ (l)$
$\Delta H°_f$ (kJ/mol)	–110.5	0	–238.6
$\Delta G°_f$ (kJ/mol)	–137.3	0	–166.2
$S°$ (J/mol K)	+197.9	???	+126.8

a) Calculate $\Delta G°$ and $\Delta H°$ for this reaction.

b) Calculate $\Delta S°$ (in J/K) for this reaction.

c) Calculate $S°$ for hydrogen.

12. At 25°C the equilibrium constant, K_p, for the reaction below is 0.281 atm.

$$Br_2\ (l) \rightleftharpoons Br_2\ (g)$$

a) What is $\Delta G°_{298}$ for this reaction?

b) If requires 193 J to vaporize 1.00 g of liquid bromine at 25°C and 1.00 atm. Calculate $\Delta H°$ and $\Delta S°$ at 25°C for this reaction.

c) Calculate the normal boiling point of bromine. Assume $\Delta H°$ and $\Delta S°$ are not affected by temperature. (***Hint***: At the normal boiling point liquid and vapor are in equilibrium)

13. ClF_3 can be prepared by the reaction shown below:

$$Cl_2\,(g) + 3\,F_2\,(g) \rightarrow 2\,ClF_3\,(g)$$

For ClF_3, $\Delta H°_f = -163.2$ kJ/mol and $\Delta G°_f = -123.0$ kJ/mol

a) Calculate the value of the equilibrium constant for this reaction at 25°C.

b) Calculate $\Delta S°$ for this reaction at 25°C.

c) If ClF_3 produced were a liquid instead of a gas, how would the ΔS for the reaction be different (sign and magnitude) than calculated above? Explain.

14. Production of ammonia from nitrogen and hydrogen gases is an important industrial reaction shown below:

$$N_2\,(g) + 3\,H_2\,(g) \rightleftharpoons 2\,NH_3\,(g)$$

$$\Delta H° = -92.38\ kJ \qquad \Delta S° = -198.3\ J/K$$

a) Calculate $\Delta G°$ for this reaction at 500°C. Assume $\Delta H°$ and $\Delta S°$ are not temperature dependent.

b) Calculate ΔG at 25°C for this reaction if the reaction mixture consists of 1.0 atm of N_2, 3.0 atm of H_2 and 1.0 atm of NH_3.

15. What are the signs of ΔH, ΔS and ΔG for the sublimation of dry ice (solid CO_2) at 25°C?

16. Using the following data, calculate the value of K_{sp} for $Ba(NO_3)_2$, one of the least soluble of the common nitrate salts.

Species	**$\Delta G°_f$**
Ba^{2+} (aq)	-561 kJ/mol
NO_3^-	-109 kJ/mol
$Ba(NO_3)_2$ (s)	-797 kJ/mol

17. Show that hydrogen cyanide (HCN) is a gas at 25°C by estimating its normal boiling point from the following data:

	$\Delta H°_f$ (kJ/mol)	**S° (J/molK)**
HCN (l)	108.9	113
HCN (g)	135.1	202