HW14 - Second Law & Free Energy

Question 1

In order for an endothermic reaction to be spontaneous,

- heat must be supplied to the system.
- the entropy increase in the system must be greater than the entropy decrease in the surroundings.
- endothermic reactions are never spontaneous.
- nothing special is required; they are always spontaneous.
- the entropy increase in the system must equal the entropy decrease in the surroundings.

Question 2

Which one of the following reactions has a positive entropy change?

- \bigcirc BF₃ (g) + NH₃ (g) \longrightarrow F₃BNH₃ (s)
- \bigcirc N₂ (g) + 3H₂ (g) \longrightarrow 2NH₃ (g)
- \bigcirc 2NH₄NO₃ (s) \longrightarrow 2N₂ (g) + 4H₂O (g) + O₂ (g)
- \bigcirc 2SO₂ (g) + O₂ (g) \longrightarrow 2SO₃ (g)
- \bigcirc H₂O (g) \longrightarrow H₂O (l)

Question 3

1 pts

Consider the following processes. Which entropy will increase as the process proceeds from left to right? Select all of the correct answers.

- □ NaCl (s) \rightarrow Na⁺ (aq) + Cl⁻ (aq)
- $\Box H_2O(I) \rightarrow H_2O(s)$
- \Box CaCO₃ (s) \rightarrow CaO (s) + CO₂ (g)

Question 4

What are the values of ΔS for the water, the surroundings, and the universe for the evaporation of water from an open pan at 25°C?

negative, negative, negative

positive, negative, zero

- positive, negative, negative
- positive, negative, positive

Question 5

True/False: For a given transfer of energy, a greater change in entropy occurs when the temperature is high.

- False, because only heat flow affects the change in entropy, not temperature.
- False, because as temperature decreases there is a greater change in entropy.
- O True

Question 6

Which of the following lists phases in order of increasing entropy?

- solid, gas, liquid
- 🔘 liquid, solid, gas
- Iiquid, gas, solid
- O gas, liquid, solid
- 🔘 solid, liquid, gas

Question 7

 H_2 burning in O_2 to form H_2O (I) is an example of a system where the entropy of the universe decreases.

- O True
- H₂ is not flammable.
- False

Question 8

Consider the following processes of ideal gases. Which of these processes leads to an increase in entropy? Select all of the correct answers.

Nitrogen gas is compressed isothermally to one half its original volume.

- □ A glass of water loses 100 J of energy reversibly at 30°C.
- The pressure of one mole of oxygen gas is allowed to double isothermally.
- Carbon dioxide is allowed to expand isothermally to 10 times its original volume.

Question 9

Which of the following chemical reactions exhibit a positive ΔS ? Select all of the correct answers.

The temperature of 2.00 mol Ne(g) is increased from 25°C to 200°C at constant pressure.

- $\Box 2H_2O(I) + O_2(g) \rightarrow H_2O_2(I)$
- $\Box 3O_2(g) \rightarrow 2O_3(g)$

 $\Box H_2O(g) \rightarrow H_2O(I)$

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

Question 10

1 pts

0.5 pts

0.5 pts

0.5 pts

0.5 pts

0.5 pts

0.5 pts

1 pts

○ -7.68 J/K	
○ -19.2 J/K	
○ +7.68 J/K	
○ +19.2 J/K	
Question 11	1 pts
The enthalpy of fusion of H ₂ O (s) at its normal melting point is entropy change for freezing 1 mole of water at this temperatur	
○ +22.0 J/mol·K	
○ +20.2 J/mol·K	
O -22.0 J/mol·K	
○ -20.2 J/mol·K	
Question 12	1 pts
Calculate the standard reaction entropy for the decomposition dioxide gas and solid calcium oxide at 25°C. $CaCO_{3}(s) \rightarrow CO_{2}(g) + CaO(s)$ $\boxed{Substance S^{\circ}(J/mol \cdot K)}$ $\boxed{CaO(s) 39.75}$ $\boxed{CO_{2}(g) 213.74}$ $\boxed{CaCO_{3}(s) 92.9}$	of 1 mol calcite to carbon
○ -266.9 J/mol*K	
○ 346.4 J/mol*K	
○ -160.6 J/mol*K	
○ 160.6 J/mol*K	
Question 13	1 pts
	1 pts
Question 13 Ture/False: All entropies of fusion are negative.	1 pts

False - fusion leads to less microstates (degrees of freedom).

False - fusion leads to more microstates (degrees of freedom).

A system releases 900 J of heat to the surroundings (27°C). What is Δ S of the surroundings?

-33.3 J/K

Question 14

- 🔘 3 J/K
- 🔘 -3 J/K

O 33.3 J/K

Question 15

When a sugar cube dissolves in a cup of coffee (an endothermic process), entropy changes of the sugar plus water, the surroundings, and the universe respectively are...

- negative, negative, negative
- negative, positive, positive
- ositive, positive, positive
- o positive, negative, negative
- None of these are correct.

Question 16

Which substance has the lower molar entropy?

They are both the same.

O There is no way to know.

- Ne (g) at 298 K and 1.00 atm
- Kr (g) at 298 K and 1.00 atm

Question 17

1 pts

Calculate the standard entropy of vaporization of ethanol at its boiling point, 352 K. The standard molar enthalpy of vaporization of ethanol at its boiling point is 40.5 kJ/mol.

-40.5 J/mol·K

- +40.5 J/mol·K
- -115 J/mol·K
- +115 J/mol·K

Question 18

Consider the following vaporization reaction. $Br_2(I) \rightarrow Br_2(g)$ At a certain pressure, ΔH° = 34 kJ/mol and ΔS° = 0.098 kJ/mol·K. What is the lowest temperature at which this process is spontaneous? 🔘 0.00288 K 🔘 -347 K

🔘 347 K

Question 19	1 pts
For this problem, you will have to look up ΔH_f° and the S° values from a table. Estir the minimum temperature at which magnetite can be reduced to iron by graphite.	nate
Fe ₃ O ₄ (s) + 2C (s, graphite) → 2CO ₂ (g) + 3Fe (s) \bigcirc 535°C	
○ 787°C	
 670°C Magenetite cannot be reduced by carbon at any temperature. 	
 Magnetite will be reduced by carbon at any temperature. 	

Question 20

What is the entropy change for the following chemical reaction at at 25°C?

$C_{2}H_{2}(g) + 2H_{2}(g) \rightarrow C_{2}H_{6}(g)$				
Substance	S° (J/K∙mol)	ΔH_{f}° (kJ/mol)		
$C_2H_2(g)$	200.94	226.73		
H ₂ (g)	130.68	0		
C ₂ H ₆ (g)	229.6	-84.68		
$C_2H_6(g)$	229.6	-84.68		

159.3 J/mol·K

- 290.0 J/mol·K
- -102.0 J/mol·K

-232.7 J/mol·K

Question 21

What is the enthalpy change for the chemical reaction in question 20?

- -142.05 kJ/mol
- O 311.41 kJ/mol
- -311.41 kJ/mol
- -538.14 kJ/mol

Question 22

Find the standard reaction free energy for the chemical reaction in question 20.

- -242.03 kJ/mol
- 69,068 kJ/mol
- -305.59 kJ/mol
- 69.07 kJ/mol

Question 23

1 pts

Assuming ΔH°_{rxn} and ΔS°_{rxn} are unaffected by temperature changes, find the temperature at which ΔG° is zero for the chemical reaction in question 20.

- 🔘 1338 K
- 🔘 -1338 K
- 🔘 1.338 K
- ΔG° will not equal 0 at any possible temperature.

Question 24

Consider the following unbalanced equation. What is the standard free energy for the reaction of 7.2 moles of Al₂O₃(s) at 298K? $AI_2O_3(s) + CO(g) \rightarrow AI(s) + CO_2(g)$

enthalpy of vaporization of chloroform is 93.7 J/mol·K and 31.4 kJ/mol, respectively.

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Substance	ΔH°_{f} (kJ/mol)	S° (J/mol·K)
$AI_2O_3(s)$	-1676.0	50.92
CO (g)	-110.5	197.6
Al (s)	0.0	28.3
CO ₂ (g)	-393.5	213.6

○ -1.1 x 10⁵ kJ

-15,000 kJ

- 🔘 810 kJ
- 🔘 5800 kJ

Question 25

Calculate the normal boiling point of chloroform given that the standard entropy and

🔘 375 K

- 🔘 335 K
- 🔘 450 K
- 🔘 405 K

Question 26

Find the standard entropy change for the formation reaction of CO (g) at 298 K. S° (J/mol⋅K) ΔH°_f (kJ/mol) Substance C (s, graphite) 5.74 0 205.14 O₂ (g) 0 CO (g) 197.67 -110.53 -89.36 J/mol·K

-13.21 J/mol·K 89.36 J/mol·K

1 pts

1 pts

1 pts

1 pts

1 pts

🔘 13.21 J/mol·K	

Question 27	1 pts
What is the standard free energy change for the chemical reaction in question 26?	

- 137.16 kJ/mol -137.16 kJ/mol
- 26,739.81 kJ/mol
- -26,739.81 kJ/mol

Question 28

Rocket fuel would be useless if its oxidation is not spontaneous. A chemist exploring potential fuels for use in space considered using vaporized aluminum chloride. What is the coefficient of O₂ (g) in the following balanced chemical equation that contains only whole numbered coefficients (i.e. no fractions)? $AICI_3(g) + O_2(g) \rightarrow AI_2O_3(s) + CIO(g)$

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Question 29

The below table contains thermodynamic data for the chemical reaction in question 28 at 2000 K. What is ΔG_{rxn} at 2000 K? Substance AC (k l/mal)

Substance	ΔG _f (kJ/mol)
$AICI_3(g)$	-467
$Al_2O_3(s)$	-1034
CIO (g)	75
○ +492 kJ/r	mol rxn
○ +700 kJ/i	mol rxn
🔘 -492 kJ/n	nol rxn
🔿 -700 kJ/n	nol rxn

Question 30

Consider the reaction in questions 28 and 29. Would this choice of reactants make a good rocket fuel?

Yes O No

It depends on the enthalpy change of the system.

- It depends on the entropy change of the system.

Question 31

Consider the following chemical reaction. Calculate ΔG° for the reaction at 298 K. $CO(g) + Cl_2(g) \rightarrow COCl_2(g)$

Substance	ΔH°_{f} (kJ/mol)	S° (J/mol·K)	
CO (g)	-110.5	197.6	
Cl ₂ (g)	0	223.0	
COCl ₂ (g)	-223.0	289.2	
○ -73.3 kJ/mol			
🔘 -39.3 kJ/mol			
○ -500.0 kJ/mol			
🔘 -151.6 kJ/mol			

Question 32

Consider the following table that contains an assortment of compounds and their corresponding standard free energies of formation. Which of these liquids are thermodynamically stable? Select all of the correct answers.

Name	Compound	Free Energy (kJ/mol)
Cyclohexane	C ₆ H ₁₂ (I)	6.4
Methanol	CH ₃ OH (I)	-166
Hydrazine	N ₂ H ₄ (I)	149
Hydrogen Peroxide	H ₂ O ₂ (I)	-120
Carbon Disulfide	CS ₂ (I)	65.3

Methanol	
Cyclohexane	
Carbon Disulfide	
Hydrogen Peroxide	
Hydrazine	

Question 33

1 pts

Ammonia (NH₃) gives windex and cat urine its odor. It has a ΔH°_{vap} of 23.35 kJ/mol and a ΔS°_{vap} of 97.43 J/mol·K. What is the normal boiling point of ammonia?

○ -0.2°C

- 273°C
- -33.3°C

○ 238.7°C

1 pts

1 pts

1 pts