HW11 - Second Law & Free Energy

This is a preview of the published version of the quiz

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Quiz Instructions

Homework 11 - Second Law & Free Energy

Question 1 **1 pts**

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.
- the entropy increase in the system must equal the entropy decrease in the surroundings.
- endothermic reactions are never spontaneous.
- nothing special is required; they are always spontaneous.

Question 2 **1 pts**

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

- $H_2O\ (g) \longrightarrow H_2O\ (l)$
- $N_2\ (g) + 3H_2\ (g) \longrightarrow 2NH_3\ (g)$
- $2SO_2\ (g) + O_2\ (g) \longrightarrow 2SO_3\ (g)$
- $2NH_4NO_3\ (s) \longrightarrow 2N_2\ (g) + 4H_2O\ (g) + O_2\ (g)$
- $BF_3\ (g) + NH_3\ (g) \longrightarrow F_3BNH_3\ (s)$

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.

- [ ] H_2O (l) → H_2O (s)
- [ ] $CaCO_3$ (s) → CaO (s) + CO_2 (g)
- [ ] NaCl (s) → Na^+ (aq) + Cl^- (aq)

Question 4

1 pts

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?

- ○ positive, negative, negative
- ○ negative, negative, negative
- ○ positive, negative, positive
- ○ positive, negative, zero

Question 5

1 pts

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

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

Question 6

1 pts

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

- solid, gas, liquid
- liquid, solid, gas
- gas, liquid, solid
- solid, liquid, gas
- liquid, gas, solid

Question 7

1 pts

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

- False
- True
- H_2 is not flammable.

Question 8

1 pts

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

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

Question 9

1 pts

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

- [ ] $2H_2O$ (l) + O_2 (g) → H_2O_2 (l)
- [ ] $3O_2$ (g) → $2O_3$ (g)
- [ ] $2H_2O$ (g) → $2H_2$ (g) + O_2 (g)
- [ ] H_2O (g) → H_2O (l)

Question 10 **1 pts**

The temperature of 2.00 mol Ne(g) is increased from 25°C to 200°C at constant pressure. Assuming the heat capacity of Ne is 20.8 J/K·mol, calculate the change in the entropy of neon. Assume ideal gas behavior.

- ◯ -19.2 J/K
- ◯ -7.68 J/K
- ◯ +7.68 J/K
- ◯ +19.2 J/K

Question 11 **1 pts**

The enthalpy of fusion of H_2O (s) at its normal melting point is 6.01 kJ/mol. What is the entropy change for freezing 1 mole of water at this temperature?

- ◯ +20.2 J/mol·K
- ◯ +22.0 J/mol·K
- ◯ -22.0 J/mol·K
- ◯ -20.2 J/mol·K

Question 12 **1 pts**

Calculate the standard reaction entropy for the decomposition of 1 mol calcite to carbon dioxide gas and solid calcium oxide at 25°C.

$CaCO_3$ (s) → CO_2 (g) + CaO (s)

Substance	S° (J/mol·K)
CaO (s)	39.75
CO_2 (g)	213.74
$CaCO_3$ (s)	92.9

- 160.6 J/mol*K
- -266.9 J/mol*K
- -160.6 J/mol*K
- 346.4 J/mol*K

Question 13

1 pts

Ture/False: All entropies of fusion are negative.

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

Question 14

1 pts

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

- 3 J/K
- -3 J/K
- 33.3 J/K
- -33.3 J/K

Question 15

1 pts

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

Question 16

1 pts

Which substance has the lower molar entropy?

- They are both the same.
- Ne (g) at 298 K and 1.00 atm
- Kr (g) at 298 K and 1.00 atm
- There is no way to know.

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.

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

Question 18

1 pts

Consider the following vaporization reaction.

$Br_2 (l) \rightarrow Br_2 (g)$

At a certain pressure, $\Delta H° = 34$ kJ/mol and $\Delta S° = 0.098$ kJ/mol·K. What is the lowest temperature at which this process is spontaneous?

- 347 K
- -347 K
- 0.00288 K
- 74 K

Question 19

1 pts

For this problem, you will have to look up $\Delta H_f°$ and the S° values from a table. Estimate the minimum temperature at which magnetite can be reduced to iron by graphite.

$Fe_3O_4 (s) + 2C (s, graphite) \rightarrow 2CO_2 (g) + 3Fe (s)$

- Magnetite will be reduced by carbon at any temperature.
- 787°C
- Magenetite cannot be reduced by carbon at any temperature.
- 670°C
- 535°C

Question 20

1 pts

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

$C_2H_2 (g) + 2H_2 (g) \rightarrow C_2H_6 (g)$

Substance	S° (J/K·mol)	ΔH_f° (kJ/mol)
C_2H_2 (g)	200.94	226.73
H_2 (g)	130.68	0
C_2H_6 (g)	229.6	-84.68

- -102.0 J/mol·K
- 290.0 J/mol·K
- 159.3 J/mol·K
- -232.7 J/mol·K

Question 21

1 pts

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

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

Question 22

1 pts

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

- -242.03 kJ/mol
- 69.07 kJ/mol
- -305.59 kJ/mol
- 69,068 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
- ΔG° will not equal 0 at any possible temperature.
- 1338 K
- 1.338 K

Question 24

1 pts

Consider the following unbalanced equation. What is the standard free energy for the reaction of 7.2 moles of Al_2O_3(s) at 298K?

Al_2O_3 (s) + CO (g) → Al (s) + CO_2 (g)

Substance	ΔH°_f (kJ/mol)	S° (J/mol·K)
Al_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

- -15,000 kJ
- 5800 kJ
- -1.1×10^5 kJ
- 810 kJ

Question 25

1 pts

Calculate the normal boiling point of chloroform given that the standard entropy and enthalpy of vaporization of chloroform is 93.7 J/mol·K and 31.4 kJ/mol, respectively.

- 450 K

375 K

335 K

405 K

Question 26

1 pts

Find the standard entropy change for the formation reaction of CO (g) at 298 K.

Substance	S° (J/mol·K)	$\Delta H°_f$ (kJ/mol)
C (s, graphite)	5.74	0
O_2 (g)	205.14	0
CO (g)	197.67	-110.53

89.36 J/mol·K

13.21 J/mol·K

-89.36 J/mol·K

-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

26,739.81 kJ/mol

-26,739.81 kJ/mol

137.16 kJ/mol

Question 28

1 pts

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 O_2 (g) in the following balanced chemical equation that contains only whole numbered coefficients (i.e. no fractions)?

$AlCl_3$ (g) + O_2 (g) → Al_2O_3 (s) + ClO (g)

- 6
- 4
- 9
- 1

Question 29

1 pts

The below table contains thermodynamic data for the chemical reaction in question 28 at 2000 K. What is ΔG_{rxn} at 2000 K?

Substance	ΔG_f (kJ/mol)
$AlCl_3$ (g)	-467
Al_2O_3 (s)	-1034
ClO (g)	75

- -700 kJ/mol rxn
- +492 kJ/mol rxn
- +700 kJ/mol rxn
- -492 kJ/mol rxn

Question 30

1 pts

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

- It depends on the entropy change of the system.
- Yes
-

It depends on the enthalpy change of the system.

No

Question 31

1 pts

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

- -39.3 kJ/mol
- -500.0 kJ/mol
- -151.6 kJ/mol
- -73.3 kJ/mol

Question 32

1 pts

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_6H_{12} (l)	6.4
Methanol	CH_3OH (l)	-166
Hydrazine	N_2H_4 (l)	149
Hydrogen Peroxide	H_2O_2 (l)	-120
Carbon Disulfide	CS_2 (l)	65.3

- [ ] Methanol
- [ ] Cyclohexane
- [ ] Hydrogen Peroxide
- [ ] Hydrazine
- [ ] Carbon Disulfide

Question 33

1 pts

Ammonia (NH_3) gives windex and cat urine its odor. It has a $\Delta H°_{vap}$ of 23.35 kJ/mol and a $\Delta S°_{vap}$ of 97.43 J/mol·K. What is the normal boiling point of ammonia?

- 273°C
- 238.7°C
- -33.3°C
- -0.2°C

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