

HW11 - Second Law & Free Energy

 This is a preview of the published version of the quiz

Started: Jul 1 at 8:12am

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?

- ☐ $\text{H}_2\text{O (g)} \longrightarrow \text{H}_2\text{O (l)}$
- ☐ $\text{N}_2 \text{ (g)} + 3\text{H}_2 \text{ (g)} \longrightarrow 2\text{NH}_3 \text{ (g)}$
- ☐ $2\text{SO}_2 \text{ (g)} + \text{O}_2 \text{ (g)} \longrightarrow 2\text{SO}_3 \text{ (g)}$
- ☐ $2\text{NH}_4\text{NO}_3 \text{ (s)} \longrightarrow 2\text{N}_2 \text{ (g)} + 4\text{H}_2\text{O (g)} + \text{O}_2 \text{ (g)}$
- ☐ $\text{BF}_3 \text{ (g)} + \text{NH}_3 \text{ (g)} \longrightarrow \text{F}_3\text{BNH}_3 \text{ (s)}$

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.

☐ $\text{H}_2\text{O} (\text{l}) \rightarrow \text{H}_2\text{O} (\text{s})$

☐ $\text{CaCO}_3 (\text{s}) \rightarrow \text{CaO} (\text{s}) + \text{CO}_2 (\text{g})$

☐ $\text{NaCl} (\text{s}) \rightarrow \text{Na}^+ (\text{aq}) + \text{Cl}^- (\text{aq})$

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

H₂ burning in O₂ to form H₂O (l) is an example of a system where the entropy of the universe decreases.

☐ False

☐ True

☐ H₂ 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.

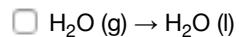
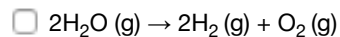
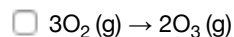
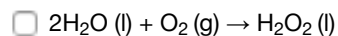
☐ Nitrogen gas is compressed isothermally to one half its original volume.

☐ 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.



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 $\text{H}_2\text{O}(\text{s})$ 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.



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**

True/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.

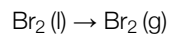
Question 17**1 pts**

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.



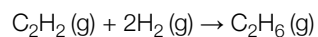
At a certain pressure, $\Delta H^\circ = 34 \text{ kJ/mol}$ and $\Delta S^\circ = 0.098 \text{ kJ/mol}\cdot\text{K}$. What is the lowest temperature at which this process is spontaneous?

☐ 347 K☐ -347 K☐ 0.00288 K☐ 74 K**Question 19****1 pts**

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

☐ Magnetite will be reduced by carbon at any temperature.☐ 787°C☐ Magnetite 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?



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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

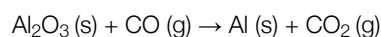
Question 23**1 pts**

Assuming $\Delta H^\circ_{\text{rxn}}$ and $\Delta S^\circ_{\text{rxn}}$ 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 $\text{Al}_2\text{O}_3(\text{s})$ at 298K?



Substance	ΔH°_f (kJ/mol)	S° (J/mol·K)
$\text{Al}_2\text{O}_3(\text{s})$	-1676.0	50.92
$\text{CO}(\text{g})$	-110.5	197.6
$\text{Al}(\text{s})$	0.0	28.3
$\text{CO}_2(\text{g})$	-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)	ΔH°_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

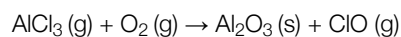
☐ -26,739.81 kJ/mol

☐ 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 $\text{O}_2(\text{g})$ in the following balanced chemical equation that contains only whole numbered coefficients (i.e. no fractions)?



☐ 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)
$\text{AlCl}_3(\text{g})$	-467
$\text{Al}_2\text{O}_3(\text{s})$	-1034
$\text{ClO}(\text{g})$	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

☐

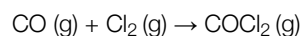
It depends on the enthalpy change of the system.

☐ No

Question 31

1 pts

Consider the following chemical reaction. Calculate ΔG° for the reaction at 298 K.



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 ₆ H ₁₂ (l)	6.4
Methanol	CH ₃ OH (l)	-166
Hydrazine	N ₂ H ₄ (l)	149
Hydrogen Peroxide	H ₂ O 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 window and cat urine its odor. It has a $\Delta H^\circ_{\text{vap}}$ of 23.35 kJ/mol and a $\Delta S^\circ_{\text{vap}}$ 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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