

This print-out should have 21 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

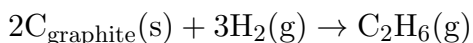
001 10.0 points

Which law of thermodynamics governs the spontaneity of reactions?

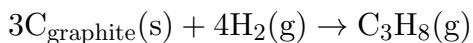
1. The 2nd Law
2. There is no thermodynamic law associated with reaction spontaneity.
3. The 1st Law
4. The 0th Law
5. The 3rd Law

002 10.0 points

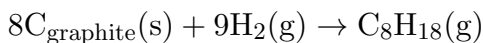
Consider the formation reactions below and pick the most stable species from the answer choices.



$$\Delta G_{\text{f}}^{\circ} = -7.86 \text{ kcal} \cdot \text{mol}^{-1}$$



$$\Delta G_{\text{f}}^{\circ} = -5.614 \text{ kcal} \cdot \text{mol}^{-1}$$



$$\Delta G_{\text{f}}^{\circ} = 4.14 \text{ kcal} \cdot \text{mol}^{-1}$$



$$\Delta G_{\text{f}}^{\circ} = 8.23 \text{ kcal} \cdot \text{mol}^{-1}$$

1. C₂H₆(g)
2. C₃H₈(g)
3. C₈H₁₈(g)

4. C₁₀H₂₂(g)

003 10.0 points

For which of the following reactions at room temperature (25 °C) would there be 5.0 kJ of work done on the system?

1. CH₂O(g) + N₂(g) + 2H₂(g) → N₂H₂(g) + CH₃OH(g)
2. CH₄(g) + 2O₂(g) → CO₂(g) + 2H₂O(g)
3. N₂H₂(g) + CH₃OH(g) → CH₂O(g) + N₂(g) + 2H₂(g)
4. 2H₂O(l) + O₂(g) → 2H₂O₂(l)
5. 2H₂O₂(l) → 2H₂O(l) + O₂(g)
6. CO₂(g) + 2H₂O(g) → CH₄(g) + 2O₂(g)

004 10.0 points

The formation of ammonia from hydrogen and nitrogen gases becomes less and less spontaneous as temperature is increased, eventually becoming non-spontaneous at sufficiently high temperatures. Which of the following statements must be true?

1. The change in entropy is large.
2. The change in entropy is small.
3. The reaction is endothermic.
4. The reaction is exothermic.

005 10.0 points

Which of the following state functions are extensive?

- I) Pressure (P)
- II) Temperature (T)
- III) Enthalpy (H)

1. II only
2. II, III

3. I, III
 4. I, II, III
 5. I only
 6. III only
 7. I, II
 8. None are true

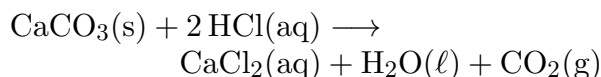
006 10.0 points

Consider the following specific heats: copper, 0.384 J/g·°C; lead, 0.159 J/g·°C; water, 4.18 J/g·°C; glass, 0.502 J/g·°C. Which substance, once warmed, would be more likely to maintain its heat and keep you warm through a long football game on a cold night?

1. glass
 2. lead
 3. copper
 4. water

007 10.0 points

Calculate the standard reaction enthalpy for the reaction of calcite with hydrochloric acid



The standard enthalpies of formation are:

- for $\text{CaCl}_2(\text{aq})$: -877.1 kJ/mol;
 for $\text{H}_2\text{O}(\ell)$: -285.83 kJ/mol;
 for $\text{CO}_2(\text{g})$: -393.51 kJ/mol;
 for $\text{CaCO}_3(\text{s})$: -1206.9 kJ/mol;
 and for $\text{HCl}(\text{aq})$: -167.16 kJ/mol.

1. -72.7 kJ/mol
 2. -38.2 kJ/mol
 3. -215 kJ/mol
 4. -116 kJ/mol

5. -165 kJ/mol
 6. -15.2 kJ/mol
 7. -98.8 kJ/mol

008 10.0 points

Estimate the heat released when ethene ($\text{CH}_2=\text{CH}_2$) reacts with HBr to give $\text{CH}_3\text{CH}_2\text{Br}$. Bond enthalpies are
 C—H : 412 kJ/mol; C—C : 348 kJ/mol;
 C=C : 612 kJ/mol; C—Br : 276 kJ/mol;
 Br—Br : 193 kJ/mol; H—Br : 366 kJ/mol.

1. 200 kJ/mol
 2. 424 kJ/mol
 3. 58 kJ/mol
 4. 1036 kJ/mol
 5. 470 kJ/mol

009 10.0 points

Which of the following is NOT a feature of the bomb calorimetry apparatus used to measure the internal energy of a reaction?

1. The heat capacity of the calorimeter should be known to accurately correct for any heat lost to it.
 2. The thermometer is inserted directly into the reaction vessel to measure ΔT of the reaction.
 3. The large heat capacity of water is beneficial in measuring heat released by combustion reactions.
 4. The volume of the reaction vessel is held constant to eliminate energy released as work.
 5. Large quantities of water surrounding the reaction vessel absorb the majority of the heat

loss.

010 10.0 points

Which of the following reactions has the largest value of ΔS° ?

1. $\text{K(s)} + \text{O}_2(\text{g}) \rightarrow \text{KO}_2(\text{s})$
2. $\text{BaCl}_2 \cdot 2 \text{H}_2\text{O(s)} \rightarrow \text{BaCl}_2(\text{s}) + 2 \text{H}_2\text{O(g)}$
3. $\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \rightarrow 2 \text{NH}_3(\text{g})$
4. $\text{NH}_3(\text{g}) + \text{HCl(g)} \rightarrow \text{NH}_4\text{Cl(s)}$
5. $2 \text{H}_2(\ell) + \text{O}_2(\ell) \rightarrow 2 \text{H}_2\text{O(g)}$

011 10.0 points

For which of the following processes does the entropy of the universe decrease?

1. None of these is correct.
2. melting one mole of ice to water at 0°C
3. freezing one mole of water to ice at 0°C
4. freezing one mole of water to ice at 0°C and then cooling it to -10°C
5. freezing one mole of water to ice at -10°C

012 10.0 points

Consider the equation



carefully, and think about the sign of ΔS for the reaction it describes. $\Delta H = +188.3 \text{ kJ}$. Which response describes the thermodynamic spontaneity of the reaction?

1. The reaction is spontaneous only at relatively low temperatures.
2. All responses are correct.
3. The reaction is spontaneous at all temperatures.

4. The reaction is not spontaneous at any temperatures.

5. The reaction is spontaneous only at relatively high temperatures.

013 10.0 points

Which of the following statements concerning the first law of thermodynamics is/are true?

- I) The internal energy of the universe is always increasing.
- II) Internal energy lost by a system is always gained by the surroundings.
- III) The universe is an isolated system.

1. I only
2. I and II only
3. II and III only
4. III only
5. I and III only
6. II only
7. I, II and III

014 10.0 points

You observe that carbon dioxide sublimates. Which of the following statements about the signs of this process is/are true?

- I) Work (w) is positive.
- II) Heat (q) is negative.
- III) Change in Gibbs free energy (ΔG) is positive.
- IV) Change in entropy (ΔS) is positive.

1. II and III
2. I only
3. I and II
4. I, II and III
5. IV only

6. III and IV

015 10.0 points

Which of the following reactions is an enthalpy of formation reaction?

1. $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \longleftrightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}$
2. $2\text{Fe}(\text{s}) + 3/2\text{O}_2(\text{g}) \longleftrightarrow \text{Fe}_2\text{O}_3(\text{s})$
3. $\text{C}_{\text{diamond}}(\text{s}) + 2\text{H}_2(\text{g}) \longleftrightarrow \text{CH}_4(\text{g})$
4. $\text{Hg}(\text{s}) + 1/2\text{O}_2(\text{g}) \longleftrightarrow \text{HgO}(\text{s})$

016 10.0 points

If we set up a bomb calorimetry experiment to determine the molar enthalpy of combustion of ethene (C_2H_4) using 1 L of water as our heat sink, 2.805 g of ethene, and measure an initial and final temperature of 25.20 °C and 58.92 °C, respectively, what will be the experimentally determined molar enthalpy of combustion of ethene? Assume the density of water is $1.00 \text{ g} \cdot \text{mL}^{-1}$. Assume the calorimeter itself absorbs no heat. The specific heat capacity of water is $4.184 \text{ J} \cdot \text{g}^{-1} \cdot \text{K}^{-1}$.

1. $-141.1 \text{ kJ} \cdot \text{mol}^{-1}$
2. $-1,411 \text{ kJ} \cdot \text{mol}^{-1}$
3. $-14,110 \text{ kJ} \cdot \text{mol}^{-1}$
4. $-14.11 \text{ kJ} \cdot \text{mol}^{-1}$
5. $-141,100 \text{ kJ} \cdot \text{mol}^{-1}$

017 10.0 points

If an MP3 player does 200 kJ of work and releases 100 kJ of heat, what is the change in internal energy for the MP3 player?

1. -300 kJ
2. 300 kJ

3. 100 kJ**4. -100 kJ**

018 10.0 points

Which of the following statements concerning the second and third laws of thermodynamics is/are true?

- I) When the change in entropy of the system is equal in magnitude and opposite in sign to the change in entropy of the surroundings, the change in entropy of the universe is zero.
- II) The change in entropy of the universe can be rewritten as $-\Delta G_{\text{system}}/T$.
- III) In a perfect, pure crystal at absolute zero the entropy of the system is zero.

1. III only**2. II, III****3. I only****4. I, III****5. II only****6. I, II, III****7. I, II**

019 10.0 points

For a given reaction, if $\Delta H_{\text{rxn}}^\circ$ is (negative/positive/either) and $\Delta S_{\text{rxn}}^\circ$ is (negative/positive/either), then the value of $\Delta G_{\text{rxn}}^\circ$ will always decrease as you raise the temperature.

1. either, positive**2. positive, either****3. either, negative****4. negative, either****5. positive, negative**

6. negative, positive

020 10.0 points

In the formula $\Delta U = q + w$, work done by the system during expansion is (negative/positive), and heat (gained/lost) by the system is positive.

1. negative, gained
2. negative, lost
3. positive, gained
4. positive, lost

021 10.0 points

Which of the following statements about the first and second laws of thermodynamics is/are true?

- I) The energy of the universe is always conserved.
- II) The energy of a system is always conserved.
- III) The energy of the system always increases.
- IV) The entropy of the universe always increases.
- V) The entropy of the universe always conserved.
- VI) The entropy of the system is always conserved.

1. III and IV
2. I and IV
3. II and V
4. II and VI
5. I and V
6. III and VI