This print-out should have 25 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

Please refer to the cover page for needed thermodynamic values and formulas.

001 10.0 points

An isolated system allows for the flow of...?

1. none of these

2. sound waves

3. kinetic energy

4. matter

5. heat

002 10.0 points

Which of the following is true of a general thermodynamic state function?

1. The change in the value of a state function is always negative for a spontaneous reaction.

2. The value of the state function remains constant.

3. The value of a state function does NOT change with a change in temperature of a process.

4. The change of the value of a state function is independent of the path of a process.

5. The change in the value of the state function is always positive for endothermic processes.

003 10.0 points

Consider the reaction

$$C_6H_{14}(\ell) + 9.5\,O_2(g) \rightarrow 6\,CO_2(g) + 7\,H_2O(\ell)$$

at constant pressure. Which response is true?

1. No work is done as the reaction occurs.

2. Work is done by the system as the reaction occurs.

3. Work is done on the system as the reaction occurs.

4. Work may be done on or by the system as the reaction occurs, depending upon the temperature.

004 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. If the same amount of heat is added to identical masses of each of these substances, which substance attains the highest temperature? (Assume that they all have the same initial temperature.)

1. copper

2. water

3. lead

4. glass

005 10.0 points

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

I) The internal energy (U) of the universe is conserved.

II) The internal energy of a system plus that of its surroundings is conserved.

III) The change in internal energy (ΔU) of a system and its surroundings can have the same sign.

1. I, II

2. III only

3. II, III

4. I only

5. I, III

6. II only

7. I, II, III

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006 10.0 points

1.95 mol of an ideal gas at 300 K and 3.00 atm expands from 16 L to 28 L and a final pressure of 1.20 atm in two steps:

(1) the gas is cooled at constant volume until its pressure has fallen to 1.20 atm, and

(2) it is heated and allowed to expand against a constant pressure of 1.20 atm until its volume reaches 28 L.

Which of the following is CORRECT?

1. $w = 0$ for the overall process

2. $w = -6.03$ kJ for the overall process

3. $w = -4.57$ kJ for (1) and $w = -1.46$ kJ for (2)

4. $w = 0$ for (1) and $w = -1.46$ kJ for (2)

5. $w = -4.57$ kJ for the overall process

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007 10.0 points

A CD player and its battery together do 500 kJ of work, and the battery also releases 250 kJ of energy as heat and the CD player releases 50 kJ as heat due to friction from spinning. What is the change in internal energy of the system, with the system regarded as the battery and CD player together?

1. −800 kJ

2. +200 kJ

3. −200 kJ

4. −700 kJ

5. −750 kJ

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008 10.0 points

The specific heat of liquid water is 4.184 J/g·°C, and of steam 2.03 J/g·°C. The heat of vaporization of water (ℓ) is 2.26 kJ/g and its boiling point is 100°C. What is the total heat flow when 18 grams of water at 12°C are heated to become steam at 109°C?

1. 44.4 kJ

2. 47.6 kJ

3. under 28 kJ

4. 48.9 kJ

5. over 55 kJ

6. 31.7 kJ

7. 40.7 kJ

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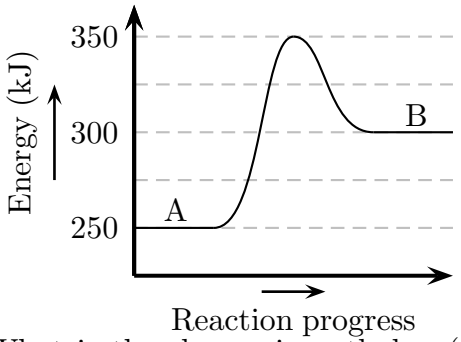
009 10.0 points

Refer to the potential energy diagram shown below.



What is the change in enthalpy (ΔH) for the reaction

$$A \rightarrow B\,?$$

1. +50 kJ, endothermic

2. −50 kJ, exothermic

3. +50 kJ, exothermic

4. −250 kJ, endothermic

5. −150 kJ, endothermic

6. −50 kJ, endothermic

7. +300 kJ, exothermic

8. −150 kJ, exothermic

9. +300 kJ, endothermic

10. −250 kJ, exothermic

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010 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. Large quantities of water surrounding the reaction vessel absorb the majority of the heat loss.

4. The volume of the reaction vessel is held constant to eliminate energy released as work.

5. The large heat capacity of water is beneficial in measuring heat released by combustion reactions.

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011 10.0 points

A 1.00 g sample of *n*-hexane (C_6H_{14}) undergoes complete combustion with excess O_2 in a bomb calorimeter. The temperature of the 1502 g of water surrounding the bomb rises from 22.64°C to 29.30°C. The heat capacity of the hardware component of the calorimeter (everything that is not water) is 4042 J/°C. What is ΔU for the combustion of *n*-C_6H_{14}? One mole of *n*-C_6H_{14} is 86.1 g. The specific heat of water is 4.184 J/g·°C.

1. -1.15×10^4 kJ/mol

2. -4.52×10^3 kJ/mol

3. -7.40×10^4 kJ/mol

4. -5.92×10^3 kJ/mol

5. -9.96×10^3 kJ/mol

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012 10.0 points

Which of the reactions below is a formation reaction?

1. $H_2(g) + C_{graphite}(s) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + H_2O(g)$

2. $2H_2(g) + 2C_{graphite}(s) + O_2(g) \rightarrow 2CH_2O(\ell)$

3. $2Fe(s) + \frac{3}{2}O_2(g) \rightarrow Fe_2O_3(s)$

4. $N_2(\ell) + 2H_2(g) \rightarrow N_2H_4(\ell)$

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013 10.0 points

Calculate the standard reaction enthalpy for the reaction

$$N_2H_4(\ell) + H_2(g) \rightarrow 2\,NH_3(g)$$

given

$N_2H_4(\ell) + O_2(g) \rightarrow N_2(g) + 2H_2O(g)$ $\quad \Delta H^\circ = -543$ kJ · mol^{-1}

$2\,H_2(g) + O_2(g) \rightarrow 2\,H_2O(g)$ $\quad \Delta H^\circ = -484$ kJ · mol^{-1}

$N_2(g) + 3\,H_2(g) \rightarrow 2\,NH_3(g)$ $\quad \Delta H^\circ = -92.2$ kJ · mol^{-1}

1. -1119 kJ · mol^{-1}

2. -151 kJ · mol^{-1}

3. -935 kJ · mol^{-1}

4. -243 kJ · mol^{-1}

5. -59 kJ · mol^{-1}

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014 10.0 points

Estimate the heat released when ethene ($CH_2{=}CH_2$) reacts with HBr to give CH_3CH_2Br.

1. 200 kJ/mol

2. 76 kJ/mol

3. 1036 kJ/mol

4. 424 kJ/mol

5. 470 kJ/mol

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015 10.0 points

Consider a reaction that is non-spontaneous at all temperatures. What would be the signs of ΔG_{sys}, ΔH_{surr}, and ΔS_{univ} respectively for such a reaction?

1. +, -, +

2. -, +, -

3. +, -, -

4. -, +, +

5. +, +, +

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016 10.0 points

Which one shows the substances in the decreasing order of their molar entropy?

1. C(s), $H_2O(\ell)$, H_2O(g), H_2O(s)

2. H_2O(g), $H_2O(\ell)$, H_2O(s), C(s)

3. None of these

4. H_2O(s), $H_2O(\ell)$, H_2O(g), C(s)

5. C(s), H_2O(g), $H_2O(\ell)$, H_2O(s)

6. C(s), H_2O(s), $H_2O(\ell)$, H_2O(g)

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017 10.0 points

Consider the following processes. (Treat all gases as ideal.)

I) The pressure of one mole of oxygen gas is allowed to double isothermally.

II) Carbon dioxide is allowed to expand isothermally to 10 times its original volume.

III) The temperature of one mole of helium is increased 25°C at constant pressure.

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

V) A glass of water loses 100 J of energy reversibly at 30°C.

Which of these processes leads to an increase in entropy?

1. III and V

2. I and II

3. I and IV

4. V

5. II and III

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018 10.0 points

What is the entropy at $T = 0$ K for one mole of chloroform ($CHCl_3$)?

1. 1.9×10^{-23} J K^{-1}

2. 1.38 J K^{-1}

3. 11.5 J K^{-1}

4. -11.5 J K^{-1}

5. 0 J K^{-1}

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019 10.0 points

What is the total non-vibrational internal energy of 10 nitrous oxide (N_2O) molecules?

1. 15 k T

2. 10 k T

3. 25 k T

4. 10 R T

5. 25 R T

6. 15 R T

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020 10.0 points

Advertising claims sometimes state that adding something mechanical to a car's engine will allow it to recover 100% of the energy that comes from burning gasoline. You should be skeptical of such claims because they violate the

1. first law of thermodynamics.

2. activation energy requirements of all chemical reactions.

3. law of conservation of matter.

4. second law of thermodynamics.

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021 10.0 points

Calculate $\Delta S^\circ_{\text{surr}}$ at 298 K for the reaction

$$6\,C(s) + 3\,H_2(g) \rightarrow C_6H_6(\ell)$$

$\Delta H^\circ_r = +49.0$ kJ·mol^{-1} and $\Delta S^\circ_r = -253$ J·K^{-1}·mol^{-1}.

1. $-$ 417 J·K^{-1}·mol^{-1}

2. $-$ 164 J·K^{-1}·mol^{-1}

3. +253 J·K^{-1}·mol^{-1}

4. $-$ 253 J·K^{-1}·mol^{-1}

5. +164 J·K^{-1}·mol^{-1}

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022 10.0 points

For the evaporation of water from an open pan at 25°C, the values of ΔS for the water, the surroundings, and the universe must be, respectively,

1. positive, positive, positive.

2. positive, negative, zero.

3. None of these is correct.

4. negative, negative, negative.

5. positive, negative, positive.

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023 10.0 points

For the reaction

$$2\,SO_3(g) \rightarrow 2\,SO_2(g) + O_2(g)$$

$\Delta H^\circ_r = +198$ kJ·mol^{-1} at 298 K. Which statement is true for this reaction?

1. The reaction is driven by the enthalpy.

2. The reaction will not be spontaneous at any temperature.

3. The reaction will not be spontaneous at high temperatures.

4. ΔG°_r will be positive at high temperatures.

5. ΔG°_r will be negative at high temperatures.

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024 10.0 points

What is ΔG°_r for the combustion of liquid *n*-pentane?

1. 3389 kJ/mol

2. $-$383 kJ/mol

3. 383 kJ/mol

4. $-$3389 kJ/mol

5. $-$451 kJ/mol

6. 451 kJ/mol

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025 10.0 points

Consider the date below regarding different allotropes of carbon.

carbon allotrope	ΔG°_f kJ · mol^{-1}
C(s, graphite)	0
C(s, diamond)	2.9
C_{60}(s, buckminsterfullerene)	24

Which of the following statements is supported by these data?

1. C_{60} is thermodynamically more stable than graphite under standard conditions.

2. Graphite could spontaneously form C_{60} under standard conditions.

3. Formation of graphite from C_{60} would be exergonic under standard conditions.

4. Diamond is the least thermodynamically stable allotrope of carbon under standard conditions.