

Name _____ Section Number _____

This test is closed note/book One 8.5 x 11 handwritten crib sheet (one sided) is permitted. Please turn off your cell phone. Use a #2 pencil.

Calculators are permitted. Computers, PDAs, and other electronic devices with a keyboard are not. Cell phones may not be used as calculators.

Complete the Scantron card as shown below. Identify your version as indicated. Scantron errors are punishable by point deductions.

A total of 50 minutes will be allotted for the exam. Answer every question. There is no penalty for guessing.

Circle Your Section

- Mindi Ogden A1 W 3-6
- Denise Enekwa A2 W 3-6
- Deborah Ortiz A3 W 3-6
- Yo-Yuan Cheng A4 W 3-6
- Wei Long A4 W 3-6
- Chiaolong Hsiao B1 Th 3-6
- Michael Rood B2 Th 3-6

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SIDE 1

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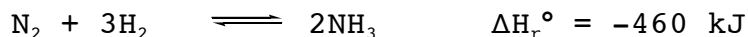
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1. The heat gained by the system from the surroundings in a process carried out at constant pressure is

- a. w
- b. ΔH
- c. $-\Delta H$
- d. ΔE
- e. ΔS

Answer: b

2. Which one of the following statements is **NOT** true concerning the equation below?



- a. The complete reaction of 1.0 mole of H_2 consumes 153 kJ of heat.
- b. The complete reaction of 1.0 mole of N_2 produces 460 kJ of heat.
- c. The production of 1.0 mole of ammonia is accompanied by the production of 230 kJ of heat.
- d. The complete reaction of 1.38 mole of hydrogen requires 0.46 mole of nitrogen.
- e. All of these are true statements.

Answer: a, the forward reaction produces heat

3. The First Law of Thermodynamics states that

- a. work and heat are interconvertable
- b. energy is conserved
- c. energy cannot be created or destroyed
- d. all of the above (a-c)
- e. none of the above

Answer: d

4. Which of the following is not a state function?

- a. q
- b. E
- c. H
- d. G
- e. All of these are state functions.

Answer: a

5. Which of the following processes has $\Delta H > 0$?

- a. combustion of a hydrocarbon (gives off heat, $\Delta H_{\text{combust}} < 0$)
- b. dilution of concentrated hydrochloric acid with water (gives off heat, $\Delta H < 0$)
- c. vaporization of water (absorbs heat, makes you, the surroundings, cold $\Delta H > 0$)
- d. freezing of liquid N_2 (gives off heat, $\Delta H < 0$)
- e. all have $\Delta H > 0$

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Answer: c

6. Calculate the $[H^+]$ in a solution that is 0.10 M in NaF and 0.20 M in HF ($K_a = 7.2 \times 10^{-4}$).

- a) $0.20 \times 10^{-1} M$
- b) $7.0 \times 10^{-4} M$
- c) $1.4 \times 10^{-3} M$
- d) $3.6 \times 10^{-4} M$
- e) none of these

Answer: c

	[HF]	[F ⁻]	[H ⁺]
I	2×10^{-1}	1×10^{-1}	10^{-7}
C	-x	x	x
E	$(2 \times 10^{-1}) - x$	$(1 \times 10^{-1}) + x$	$10^{-7} + x$

Assume $10^{-1} \gg x \gg 10^{-7}$

$$K_a = [H^+][F^-] = (10^{-7})(x)/(2 \times 10^{-1}) \quad x = 7.2 \times 10^{-4}(2 \times 10^{-1})(10^{-7}) = 1.4 \times 10^{-3}$$

7. What quantity of NaOH(s) must be added to 1.00 L of 0.200 M HCl to achieve a pH of 12.0? (assume constant volume.)

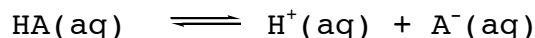
- a) 0.20 mole
- b) 0.42 mole
- c) 0.21 mole
- d) 0.01 mole
- e) none of these

Answer: c

0.2 moles are required to bring the pH to 7 (neutralize the HCl).

0.01 moles are required to bring the pH from 7 to 12.

8. Consider the solution buffered by the weak acid HA.



Which of the statements below is false?

- a) Addition of NaCl(s) to produce Na⁺(aq) and Cl⁻(aq) will change the pH. **False: NaCl is not an acid or base, and there is no common ion.**
- b) If the ratio of $[A^-]/[HA]$ is constant, the pH is constant. **True: $pH = pK_a + \log[A^-]/[HA]$**
- c) The solution resists change in pH when acid or base is added. **True: that is the definition of a buffer.**
- d) The buffering capacity is maximum when $pH = pK_a$. **True: $pH = pK_a + \log[A^-]/[HA]$ and the % change of $[A^-]/[HA]$ with change in $[A^-]$ is a minimum when $[A^-]/[HA] = 1$.**
- e) $pH = pK_a + \log[A^-]/[HA]$. **True: That is the Henderson-Hasselbalch equation.**

Answer: a

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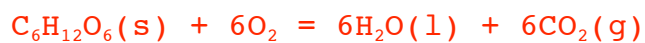
Given the following enthalpies of formation:

Species	ΔH_f° (kJ mol ⁻¹)
glucose [C ₆ H ₁₂ O ₆ (s)]	-1274
CO ₂ (g)	-393
H ₂ O(l)	-286

9. What is the standard enthalpy of combustion of glucose to form carbon dioxide and liquid water.

- 2800 kJ mol⁻¹
- 1953 kJ mol⁻¹
- 595 kJ mol⁻¹
- 595 kJ mol⁻¹
- none of these

Answer: a



$$\Delta H_f^\circ(\text{O}_2) = 0$$

$$\Delta H_r^\circ = 6(-286) + 6(-393) - (-1274) = -1716 - 2358 + 1274 = -2800 \text{ kJ mol}^{-1}$$

A perfect gas is very slowly compressed from 45 L to 18 L at a constant external pressure of 5.0 atm. During this process 9.8 kJ of energy is released as heat.

10. The heat q for this process is

- 135 kJ
- 135 kJ
- 9.8 kJ
- 9.8 kJ
- 270 kJ

Answer: c, if q is released to the surroundings, $q_{\text{sys}} < 0$.

11. The work w for this process is

- 9.82 L atm
- 9.82 L atm
- 135 L atm
- 135 L atm
- 270 kJ

Answer: c $w = -P\Delta V = -5(18-45) = 135 \text{ L atm}$

12. In any process, $\Delta E_{\text{univ}} =$

- 0
- ΔE_{sys}
- ΔE_{surr}
- $-\Delta E_{\text{sys}}$
- $-\Delta E_{\text{surr}}$

Answer: a

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13. Given the following ΔH_f° values:

SiH ₄ (g)	34.3 kJ mol ⁻¹
SiO ₂ (s)	-910.9 kJ mol ⁻¹
H ₂ O(l)	-285.8 kJ mol ⁻¹
O ₂ (g)	0.0 kJ mol ⁻¹

Also,

$$\text{H}_2\text{O} \quad \Delta H_{\text{vap}} = 44.0 \text{ kJ mol}^{-1}.$$

Calculate ΔH_r° for $\text{SiH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightleftharpoons \text{SiO}_2(\text{s}) + 2\text{H}_2\text{O}(\text{s})$.

- 1517 kJ mol⁻¹
- 1429 kJ mol⁻¹
- 1187 kJ mol⁻¹
- This cannot be determined without additional information.
- none of these

Answer: d, you need to know ΔH_{fusion} for H₂O.

14. The second law of thermodynamics states that

- energy is conserved in spontaneous processes.
- the heat content of the universe increases during a spontaneous process.
- the entropy of the universe increases during a spontaneous process.
- the entropy of a perfect crystal is zero at absolute zero.
- work and heat are interconvertible.

Answer: c15. For the vaporization of a liquid at its boiling point T_b , the change in entropy and the change in enthalpy are related by

- $\Delta S_{\text{vap}} = \Delta H_{\text{vap}}/T_b$
- $\Delta S_{\text{vap}} = T_b \Delta H_{\text{vap}}$
- $\Delta S_{\text{vap}} = T_b / \Delta H_{\text{vap}}$
- $T_b = \Delta H_{\text{vap}} \Delta S_{\text{vap}}$
- There is no general relation covering these vaporization quantities.

Answer: a, at the boiling point $0 = \Delta G = \Delta H_{\text{vap}} - T_b \Delta S_{\text{vap}}$ 16. If ΔS_{univ} is positive for a process, the process is _____, if ΔS_{univ} for a process is negative, the process is _____, and if the ΔS_{univ} for a process is zero, the process is _____.

- at equilibrium, spontaneous, nonspontaneous
- nonspontaneous, spontaneous, at equilibrium
- spontaneous, at equilibrium, nonspontaneous
- spontaneous, nonspontaneous, at equilibrium
- none of these

Answer: d

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17. A process can proceed spontaneously in the forward direction at low temperatures and in the reverse direction at high temperatures if
- ΔH is positive and ΔS is negative.
 - ΔH is negative and ΔS is positive.
 - both ΔH and ΔS are positive.
 - both ΔH and ΔS are negative.
 - This cannot be answered in such a general way.

Answer: d: $\Delta G = \Delta H - T\Delta S$. At low T the ΔH term dominates and $\Delta H < 0$ will drive reaction forward. At high T, $T\Delta S$ term dominates and $\Delta S < 0$ will drive the reaction in reverse.

18. Methyl orange is an indicator with a K_a of 10^{-4} . The protonated form of methyl orange is red, while the deprotonated form is yellow. At pH 6.0, the indicator will be
- red.
 - orange.
 - yellow.
 - blue.
 - not enough information

Answer: c: When the $\text{pH} > \text{p}K_a$, the predominant species is deprotonated. ($\text{p}K_a = 4$)

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19. I have followed the instructions on the first page. I have entered my GT number, my name, the exam version, and my section number.

- a. True
- b. False

Answer: a

20. This is exam version:

- a. A
- b. B
- c. C

Answer: A,B,C

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Constants:

1 mole = 6.022×10^{23} atoms

1 mole = 6.022×10^{23} molecules

1 mole = 6.022×10^{23} ions

$h = 6.626 \times 10^{-34} \text{ Js}$

1 J (Joule) = $1 \text{ kg} \frac{\text{m}^2}{\text{s}^2}$

$c = 3.0 \times 10^8 \text{ m/s}$

Mass of an Electron = $9.10939 \times 10^{-31} \text{ kg}$

Mass of a Proton = $1.67 \times 10^{-27} \text{ kg}$

Mass of a Neutron = $1.67 \times 10^{-27} \text{ kg}$

$R = 0.0821 \frac{\text{Latm}}{\text{molK}}$

$R = 8.31 \frac{\text{J}}{\text{molK}}$

$V.P.(H_2O, 373K) = 760 \text{ torr}$

Stoichiometry:

$Density = \frac{mass}{volume}$

$Molarity = M = \frac{\text{mole of solute}}{\text{L of solvent}}$

$n \text{ (number of moles)} = \frac{mass}{\text{Molar Mass}}$

Quantum Mechanics

$c = \lambda \nu$

$E = mc^2$

$\lambda = \frac{h}{p}$

$\hat{H}\psi = E\psi$

$\Delta x * m\Delta v \geq \frac{h}{4\pi}$

Maximum Occupancy = $2n^2$

Solubility Rules

1. All alkali metal salts are soluble.
2. All ammonium (NH_4^+) salts are soluble.
3. All chlorides, bromides, and iodides are soluble except those of Ag^+ , Hg_2^{2+} , and Pb^{2+} .
4. All nitrates, chlorates, and perchlorates are soluble.
5. All sulfates except those of Ca^{2+} , Sr^{2+} , Ba^{2+} , Pb^{2+} , Hg_2^{2+} , and Ag^+ .
6. All carbonates, chromates, oxalates, and phosphates are insoluble except those of the alkali metals and ammonium.
7. All hydroxides are insoluble except those of the alkali metals.

Bonding

Formal Charge = $V - (L + 0.5 S)$

V = Number of Valence Electrons

L = The Number of Lone Pair Electrons

S = The Number of Shared Electrons

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Solutions

$$P = X_1 \cdot P^o$$

$$m = \text{molality} = \frac{\text{mol of solute}}{\text{kg of solvent}}$$

$$\Delta T_f = -m \cdot K_f$$

$$\Delta T_b = m \cdot K_b$$

$$X_1 = \text{mole fraction} = \frac{n_1}{n_{\text{total}}}$$

$$\Pi = MRT$$

Gas Laws

$$P_1V_1 = P_2V_2$$

$$V_1T_2 = V_2T_1$$

$$PV = nRT$$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\text{Kelvin} = ^\circ\text{C} + 273.15$$

$$(P + a \frac{n^2}{V^2})(V - nb) = nRT$$

$$P_{\text{total}} = P_1 + P_2 + \dots + P_n$$

$$KE(\text{mol}) = \frac{3}{2} RT \text{ (monoatomic)}$$

$$KE(\text{particle}) = \frac{1}{2} mu^2$$

Thermodynamics

$$E = q + w$$

$$w = -P_{\text{ext}}\Delta V$$

$$C_p = \frac{5}{2} R \text{ (monoatomic ideal gas)}$$

$$C_v = \frac{3}{2} R \text{ (monoatomic ideal gas)}$$

$$\Delta H = q_p \text{ (constant temperature)}$$

$$w_{\text{rev}} = -nRT \ln\left(\frac{V_2}{V_1}\right)$$

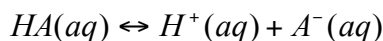
Acid-Base

$$pH = -\log[H^+]$$

$$pOH = -\log[OH^-]$$

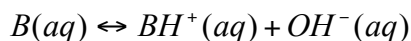
$$K_w = K_a K_b$$

$$pH + pOH = 14$$



$$K_a = \frac{[H^+][A^-]}{[HA]}$$

$$K_w = 1 \times 10^{-14} \text{ at } 25^\circ\text{C}$$



$$K_b = \frac{[BH^+][OH^-]}{[B]}$$

$$pKa = -\log K_a$$

$$pKw = 14 \text{ at } 25^\circ\text{C}$$

$$pH = pKa + \log\left(\frac{[\text{base}]}{[\text{acid}]}\right)$$

$$q = mC\Delta T$$

$$q_v = nC_v\Delta T$$

$$q_p = nC_p\Delta T$$

$$dS = \frac{dq}{T}$$

$$\Delta G = \Delta H - T\Delta S$$

$$\Delta G = -RT \ln K$$

$$T_c = \frac{\Delta H}{\Delta S}$$

$$C_{\text{water}} = 4.184 \frac{J}{\text{molK}}$$