

CHS 1440-0001
Exam **4** version **A**

Fall Semester, Dec. 2021
A **UCF ID** is required.

On your pink TEST FORM, write your correct **Name** and the **Date**.

Shade in the following: correct **PID**; **test version (form)**. **Your grade cannot be posted in webcourses if your PID or test form, or both, are incorrect or missing!**

Use of a nonprogrammable (nongraphing) calculator is permitted, e.g., TI-30X series! No graphing calculators, nor cell phones. All other electronic devices should be properly stored away.

Read the questions and the answers carefully. Write/work on the test!

*Choose the correct answer to each question. There are **20** questions with 5 choices, a-e!!*

A periodic table is attached.

The useful constants and relationships are attached.

1. On the basis of your experience, predict which of the following reactions are spontaneous.

- 1) $\text{NaCl}(s) \rightarrow \text{NaCl}(l)$ at 25°C
- 2) $2 \text{NaCl}(s) \rightarrow 2 \text{Na}(s) + \text{Cl}_2(g)$
- 3) $\text{CO}_2(g) \rightarrow \text{CO}_2(s)$ at 25°C
- 4) $\text{CO}_2(g) \rightarrow \text{C}(s) + \text{O}_2(g)$
- 5) $\text{H}_2\text{O}(s) \rightarrow \text{H}_2\text{O}(l)$ at 25°C

a) 1, 2, and 3 b) 1, 2, and 4 c) 3 and 5 d) 3 **e) 5**

2. Without doing a calculation, predict which of the following shows an *increase* in entropy?

- 1) $\text{CO}_2(g) \longrightarrow \text{CO}_2(s)$
- 2) $\text{FeCl}_2(s) + \text{H}_2(g) \longrightarrow \text{Fe}(s) + 2\text{HCl}(g)$
- 3) $\text{CO}(g) + 2 \text{H}_2(g) \longrightarrow \text{CH}_3\text{OH}(l)$
- 4) $2\text{H}_2\text{O}(g) \longrightarrow 2\text{H}_2(g) + \text{O}_2(g)$
- 5) $\text{H}_2\text{O}(s) \longrightarrow \text{H}_2\text{O}(l)$

a) 1, 2, and 4 **b) 2, 4, and 5** c) 3 and 5 d) 1 and 3 e) 4 and 5

3. The sign of ΔH_{rxn} and ΔS_{rxn} for several reactions are given. In which case is the reaction nonspontaneous at all temperatures?

- (a) $\Delta H_{\text{rxn}} < 0$; $\Delta S_{\text{rxn}} < 0$
- (b) $\Delta H_{\text{rxn}} < 0$; $\Delta S_{\text{rxn}} > 0$
- (c) $\Delta H_{\text{rxn}} > 0$; $\Delta S_{\text{rxn}} < 0$**
- (d) $\Delta H_{\text{rxn}} > 0$; $\Delta S_{\text{rxn}} > 0$
- (e) $\Delta H_{\text{rxn}} = \Delta S_{\text{rxn}}$

4. Select the correct statement that corresponds to the second law of thermodynamics.

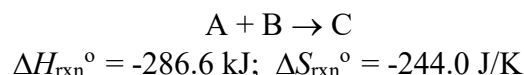
- (a) The standard Gibbs free energy change, ΔG° , can be calculated from Gibbs free energies of formation, ΔG_f°
- (b) The entropy of a perfect crystal of any pure substance approaches zero, as the temperature approaches absolute zero (0 K)
- (c) The entropy change for a reaction, ΔS° , can be calculated from the standard molar entropies of the reactants and products
- (d) $\Delta E_{\text{universe}} = \Delta E_{\text{system}} + \Delta E_{\text{surroundings}} = 0$

(e) In any spontaneous process, $\Delta S_{\text{universe}} = \Delta S_{\text{system}} + \Delta S_{\text{surroundings}} > 0$

5. Which statement is true for the melting of ice cube at 25 °C?

- a) ΔH is positive; ΔS is positive; ΔG is positive.
- b) ΔH is positive; ΔS is positive; ΔG is negative.
- c) ΔH is negative; ΔS is positive; ΔG is negative.
- d) ΔH is positive; ΔS is negative; ΔG is positive.
- e) ΔH is negative; ΔS is negative; ΔG is negative.

6. Confirm that the reaction below would be spontaneous, or nonspontaneous at 45°C, by calculating the standard free energy change, ΔG° , using values for ΔH° and ΔS° .



- (a) -209 kJ; the reaction is spontaneous at 45°C.
- (b) +209 kJ; the reaction is nonspontaneous at 45°C.
- (c) -531 kJ; the reaction is spontaneous at 45°C.
- (d) +43 kJ; the reaction is not spontaneous at 45°C.
- (e) -43 kJ; the reaction is spontaneous at 45°C.

7. For which of the following substances is $\Delta H_f^\circ = 0$; $\Delta G_f^\circ = 0$?

- 1) Al(g)
- 2) C(s, diamond)
- 3) C(s, graphite)
- 4) CO₂(g)
- 5) O₂(g)

a) 1, 3, and 5 b) 2, 3, and 5 c) 3 and 5 d) 2 and 3 e) 5

8. When magnesium sulfite decomposes, the solid transforms into magnesium oxide and sulfur dioxide.



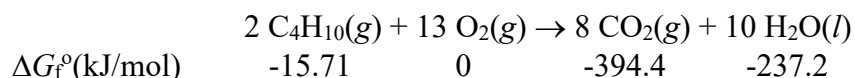
At what temperature will this reaction be spontaneous according to Gibb's Energy?

ΔH_f° in kJ/mol for: $\text{MgSO}_3(s) = -1068$, $\text{MgO}(s) = -601.8$, $\text{SO}_2(g) = -296.8$

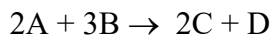
S° in J/mol K for: $\text{MgSO}_3(s) = 121$, $\text{MgO}(s) = 27$, $\text{SO}_2(g) = 248.1$

- (a) temps below -63.1 K
- (b) temps below 179.5 K
- (c) temps below 415.8 K
- (d) temps above 415.8 K
- (e) temps above 1100 K

9. Confirm that the reaction below would be spontaneous, or nonspontaneous at 25°C , by calculating the standard free energy change, ΔG° , using values for ΔG_f° .

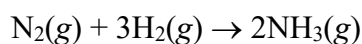


- (a) -615.89 kJ; the reaction is spontaneous.
 - (b) $+615.89$ kJ; the reaction is not spontaneous.
 - (c) 0 kJ; the reaction is spontaneous.
 - (d) $+5496$ kJ; the reaction is not spontaneous.
 - (e) -5496 kJ; the reaction is spontaneous.
10. If a 5.0 L flask holds 0.125 moles of nitrogen at STP, what happens to the entropy of the system upon heating the gas to 125°C ?
- (a) The entropy is zero.
 - (b) The entropy increases.
 - (c) The entropy remains the same.
 - (d) The entropy decreases.
 - (e) There is too little information to assess the change.
11. In the first 10.0 s of the reaction, the concentration of A decreased from 0.48 M to 0.12 M. What is the rate of the reaction in this time interval?



- (a) $1.2 \times 10^{-2} \text{ M/s}$
- (b) 0.36 M/s
- (c) 0.18 M/s
- (d) $3.6 \times 10^{-2} \text{ M/s}$
- (e) $1.8 \times 10^{-2} \text{ M/s}$

12. If ammonia, $\text{NH}_3(\text{g})$, is being produced at a rate of $4.26 \times 10^{-5} \text{ mol L}^{-1} \text{ s}^{-1}$, at what rate is hydrogen gas being consumed?



- (a) $1.42 \times 10^{-5} \text{ mol L}^{-1} \text{ s}^{-1}$.
- (b) $2.13 \times 10^{-5} \text{ mol L}^{-1} \text{ s}^{-1}$.
- (c) $4.26 \times 10^{-5} \text{ mol L}^{-1} \text{ s}^{-1}$.
- (d) $6.39 \times 10^{-5} \text{ mol L}^{-1} \text{ s}^{-1}$
- (e) $1.28 \times 10^{-4} \text{ M/s}$

13. Based on the generic rate law, which of the following are correct?

$$\text{Rate of reaction} = k[\text{A}]^m [\text{B}]^n$$

- 1) The experimentally determined exponents (m, n) are referred to as the order of the reaction with respect to A and B, respectively.
- 2) If $m = 1$, the reaction is first order with respect to A.
- 3) If $m = 0$, the reaction is independent of the concentration of B.
- 4) If $n = 2$, the reaction is second order with respect to A.
- 5) The overall order of the reaction = $m + n$

- a) 1, 2, and 5 b) 2, 3, and 4 c) 1 and 5 d) 4 and 5 e) 5

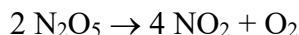
14. Consider the reaction: $2A + B \rightarrow C$, and a kinetics study on this reaction yielded:

$[\text{A}] \text{ mol} \cdot \text{L}^{-1}$	$[\text{B}] \text{ mol} \cdot \text{L}^{-1}$	Rate = $\text{mol} \cdot \text{L}^{-1} \cdot \text{s}^{-1}$
0.100	0.200	5.01×10^{-3}
0.050	0.200	1.25×10^{-3}
0.050	0.100	1.26×10^{-3}

What is the value of the rate constant?

- (a) $3.20 \text{ L}\cdot\text{mol}^{-1}\cdot\text{s}^{-1}$
- (b) $19.8 \text{ L}\cdot\text{mol}^{-1}\cdot\text{s}^{-1}$
- (c) $0.501 \text{ L}\cdot\text{mol}^{-1}\cdot\text{s}^{-1}$
- (d) $4.60 \text{ L}\cdot\text{mol}^{-1}\cdot\text{s}^{-1}$
- (e) 4.60 s^{-1}

15. The decomposition of N_2O_5 in solution of carbon tetrachloride is a first-order reaction:



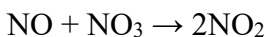
The rate constant at a given temperature is found to be $5.25 \times 10^{-4} \text{ s}^{-1}$. If the initial concentration of N_2O_5 is 0.200 M, what is its concentration after exactly 10 minutes have passed?

- (a) 0.000 M
- (b) 0.073 M
- (c) 0.146 M
- (d) 0.167 M
- (e) 0.191 M

16. Consider the decomposition of N_2O_5 by the following equation.



The mechanism includes three elementary steps:



Which species is a reactive intermediate?

- 1) O_2
- 2) NO
- 3) NO_2
- 4) NO_3
- 5) N_2O_5

- a) 1, 3, and 5 b) 2 and 4 c) 3 and 4 d) 4 e) all of them

17. If a reaction is zero order with respect to $[\text{A}]$, doubling the concentration of $[\text{A}]$ will result in:

- (a) a doubling of the rate

- (b) a tripling of the rate
- (c) a four-fold increase in rate
- (d) an eight-fold increase in rate
- (e) no change in the rate of reaction

18. If the initial concentration of the reactant in a first-order reaction $A \rightarrow \text{products}$ is 0.64 mol/L and the half-life is 30.0 s, how long would it take for the concentration of the reactant to drop to 0.020 mol/L?

- (a) 30.0 s
- (b) 60.0 s
- (c) 90.0 s
- (d) 120.0 s
- (e) 150.0 s

19. Consider the elementary step: $2X \rightarrow Z$. What type of elementary step is this?

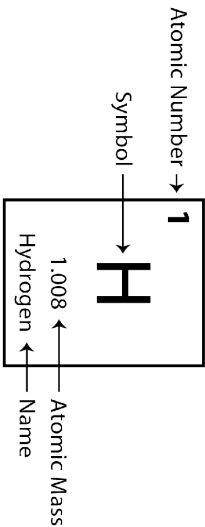
- (a) unimolecular
- (b) bimolecular
- (c) termolecular
- (d) all of the above
- (e) none of the above

20. Raising the temperature of a reaction elevates the rate of reaction by:

- (a) increasing the energy of activation
- (b) creating more molecules in the reaction.
- (c) providing a new reaction mechanism
- (d) increasing the number of molecules moving at a speed sufficiently high enough to produce a reactive collision.
- (e) decreasing the entropy of the system.

End.....

1	H 1.0079 Hydrogen	2	He 4.0026 Helium
Atomic Number → 1			
Symbol →		Atomic Mass	
H		1.008	
← Hydrogen		← Name	
3	Li 6.941 Lithium	5	B 10.811 Boron
4	Be 9.0122 Beryllium	6	C 12.011 Carbon
11	Na 22.9898 Sodium	13	Al 26.9815 Aluminium
12	Mg 24.3050 Magnesium	14	Si 28.0855 Silicon
19	K 39.0983 Potassium	15	P 30.9738 Phosphorus
20	Ca 40.078 Calcium	16	S 32.065 Sulfur
21	Sc 44.9559 Scandium	17	Cl 35.453 Chlorine
22	Ti 47.87 Titanium	18	Ar 39.948 Argon
23	V 50.9415 Vanadium		
24	Cr 51.9961 Chromium		
25	Mn 54.9380 Manganese		
26	Fe 55.85 Iron		
27	Co 58.9332 Cobalt		
28	Ni 58.6934 Nickel		
29	Cu 63.546 Copper		
30	Zn 65.38 Zinc		
31	Ga 69.723 Gallium		
32	Ge 72.64 Germanium		
33	As 74.9216 Arsenic		
34	Se 78.96 Selenium		
35	Br 79.904 Bromine		
36	Kr 83.80 Krypton		
37	Rb 85.4678 Rubidium		
38	Sr 87.62 Strontium		
39	Y 88.9059 Yttrium		
40	Zr 91.224 Zirconium		
41	Nb 92.9064 Niobium		
42	Mo 95.96 Molybdenum		
43	Tc 98 Technetium		
44	Ru 101.07 Ruthenium		
45	Rh 102.9055 Rhodium		
46	Pd 106.42 Palladium		
47	Ag 107.8682 Silver		
48	Cd 112.411 Cadmium		
49	In 114.82 Indium		
50	Sn 118.710 Tin		
51	Sb 121.76 Antimony		
52	Te 127.60 Tellurium		
53	I 126.9045 Iodine		
54	Xe 131.29 Xenon		
55	Cs 132.9055 Caesium		
56	Ba 137.327 Barium		
57 71			
72	Hf 178.49 Hafnium		
73	Ta 180.9479 Tantalum		
74	W 183.84 Tungsten		
75	Re 186.207 Rhenium		
76	Os 190.2 Osmium		
77	Ir 192.22 Iridium		
78	Pt 195.08 Platinum		
79	Au 196.9665 Gold		
80	Hg 200.59 Mercury		
81	Tl 204.3833 Thallium		
82	Pb 207.2 Lead		
83	Bi 208.9804 Bismuth		
84	Po 209 Polonium		
85	At 210 Astatine		
86	Rn 222 Radon		
87	Fr 223 Francium		
88	Ra 226 Radium		
89 103			
104	Rf 267 Rutherfordium		
105	Db 268 Dubnium		
106	Sg 269 Seaborgium		
107	Bh 270 Bohrium		
108	Hs 269 Hassium		
109	Mt 278 Meitnerium		
110	Ds 281 Darmstadtium		
111	Rg 281 Roentgenium		
112	Cn 285 Copernicium		
113	Uut 286 Ununtrium		
114	Fl 289 Flerovium		
115	Uup 289 Ununpentium		
116	Lv 293 Livermorium		
117	Uus 294 Ununseptium		
118	Uuo 294 Ununoctium		



										Lanthanide Series									
										57	58	59	60	61	62	63	64	65	66
										La 138.9055 Lanthanum	Ce 140.116 Cerium	Pr 140.9076 Praseodymium	Nd 144.24 Neodymium	Pm 145 Promethium	Sm 150.36 Samarium	Eu 151.964 Europium	Gd 157.25 Gadolinium	Tb 158.9253 Terbium	Dy 162.50 Dysprosium
										89	90	91	92	93	94	95	96	97	98
										Ac 227 Actinium	Th 232.0381 Thorium	Pa 231.0359 Protactinium	U 238.0289 Uranium	Np 237 Neptunium	Pu 244 Plutonium	Am 243 Americium	Cm 247 Curium	Bk 247 Berkelium	Cf 251 Californium
										Actinide Series									
										99	100	101	102	103					
										Es 252 Einsteinium	Fm 257 Fermium	Md 258 Mendelevium	No 259 Nobelium	Lr 262 Lawrencium					

SOME USEFUL CONSTANTS

(a more complete list appears in Appendix B)

Atomic mass unit	$1 \text{ amu} = 1.6606 \times 10^{-24} \text{ g}$
Avogadro's number	$N = 6.02214179 \times 10^{23} \text{ particles/mol}$
Electronic charge	$e = 1.60218 \times 10^{-19} \text{ coulombs}$
Faraday constant	$F = 96,485.3399 \text{ coulombs/mol } e^{-}$
Gas constant	$R = 0.08206 \frac{\text{L atm}}{\text{mol K}} = 1.987 \frac{\text{cal}}{\text{mol K}}$ $= 8.314472 \frac{\text{J}}{\text{mol K}} = 8.314472 \frac{\text{kPa dm}^3}{\text{mol K}}$
Pi	$\pi = 3.1415927$
Planck's constant	$h = 6.62606896 \times 10^{-34} \text{ J s}$
Speed of light (in vacuum)	$c = 2.99792458 \times 10^8 \text{ m/s}$

SOME USEFUL RELATIONSHIPS

Mass and Weight

SI Base Unit: Kilogram (kg)

- 1 kilogram = 1000 grams = 2.205 pounds
- 1 gram = 1000 milligrams
- 1 pound = 453.59 grams
- 1 amu = 1.6606×10^{-24} grams
- 1 gram = 6.022×10^{23} amu
- 1 ton = 2000 pounds

Volume

SI Base Unit: Cubic Meter (m^3)

- 1 liter = 0.001 cubic meter
- 1 liter = 1000 cubic centimeters = 1000 mL
- 1 liter = 1.056 quarts
- 1 quart = 0.9463 liter
- 1 milliliter = 0.001 liter = 1 cubic centimeter
- cubic foot = 7.475 gallons = 28.316 liters
- 1 gallon = 4 quarts

Pressure

SI Base Unit: Pascal (Pa)

- $1 \text{ pascal} = \frac{\text{kg}}{\text{m s}^2} = 1 \text{ Newton/m}^2$
- 1 atmosphere = 760 torr
- = 760 millimeters of mercury
- = 1.01325×10^5 pascals
- = 1.01325 bar
- = 14.70 pounds per square inch
- 1 torr = 1 millimeter of mercury

Length

SI Base Unit: Meter (m)

- 1 inch = 2.54 centimeters (exactly)
- 1 meter = 100 centimeters = 39.37 inches
- 1 yard = 0.9144 meter
- 1 mile = 1.609 kilometers
- 1 kilometer = 1000 meters = 0.6215 mile
- 1 Ångstrom = 1.0×10^{-10} meters = 1.0×10^{-8} centimeters

Energy

SI Base Unit: Joule (J)

- 1 calorie = 4.184 joules = 4.129×10^{-2} L atm
- 1 joule = $1 \frac{\text{kg m}^2}{\text{s}^2} = 0.23901 \text{ calorie}$
- 1 joule = 1×10^7 ergs
- 1 electron volt = 1.6022×10^{-19} joule
- 1 electron volt = 96.485 kJ/mol
- 1 L atm = 24.217 calories = 101.325 joules

Temperature

SI Base Unit: Kelvin (K)

- 0 K = -273.15°C
- K = $^\circ\text{C} + 273.15^\circ$
- $^\circ\text{F} = 1.8(^\circ\text{C}) + 32^\circ$
- $^\circ\text{C} = \frac{^\circ\text{F} - 32^\circ}{1.8^\circ}$