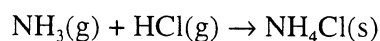


1. A reaction that is spontaneous _____.

b

- (a) will be very rapid as written
- (b) will proceed as written without outside intervention
- (c) is also spontaneous in the reverse direction
- (d) has an equilibrium position that lies very far to the left

2. Consider the reaction:



Given the following table of thermodynamic data, determine the temperature (in °C) above which the reaction is nonspontaneous.

a + d
correct

Substance	ΔH_f° (kJ/mol)	S° (J/mol-K)
$\text{NH}_3(\text{g})$	-46.19	192.5
$\text{HCl}(\text{g})$	-92.30	186.69
$\text{NH}_4\text{Cl}(\text{s})$	-314.4	94.6

Right
answer

- (a) 345.1
- (b) 432.8
- (c) 1235
- (d) 618.1

Answer
in K

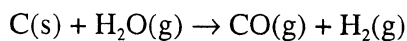
$$\Delta G = \Delta H - T\Delta S$$

$$0 = -175.91 \times 10^3 \text{ J} - (T)(-284.59)$$

$$T = 618.1 \text{ K}$$

$$T = 345.1 \text{ }^\circ\text{C}$$

3. Consider the following reaction at 25 °C.



For this reaction, $\Delta G^\circ = 91.2 \text{ kJ}$ and $\Delta S^\circ = 135 \text{ J/K}$.

What is the value of ΔH° (kJ) for this reaction at 25 °C?

- (a) 131.4
- (b) 40.3
- (c) 226
- (d) 91.3

9

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

$$91.2 \times 10^3 \text{ kJ} = \Delta H - (298 \text{ K})(135 \frac{\text{J}}{\text{K}})$$

$$\Delta H = 131.4 \text{ kJ}$$

4. How does the number of degrees of freedom of a molecule relate to its entropy?

d

- (a) the fewer the number of degrees of freedom, the greater the entropy
- (b) the greater the number of degrees of freedom, the lower the entropy
- (c) there is no relationship between the number of degrees of freedom and the entropy
- (d) the greater the number of degrees of freedom, the greater the entropy

5. Determine the pH of a solution prepared by adding 0.45 mol of solid $\text{KC}_2\text{H}_3\text{O}_2$ to 1.00 L of 2.00 M $\text{HC}_2\text{H}_3\text{O}_2$ (acetic acid). For acetic acid $K_a = 1.8 \times 10^{-5}$.

b

- (a) 2.22
- (b) 4.10
- (c) 5.32
- (d) 4.74

$$\text{pH} = 4.74 + \log\left(\frac{0.45}{2}\right)$$

$$\text{pH} = 4.09$$

6. 65.50 mL of 0.161 M HF is titrated with 0.1200 M NaOH. What is the pH when 25.00 mL of base have been added? (K_a for HF = 6.8×10^{-4})

b

- (a) 2.12
- (b) 2.77
- (c) 3.55
- (d) 5.12

$$0.161 \text{ mol/L HF} \times 0.06550 \text{ L} = 0.0105 \text{ mol HF}$$

$$0.1200 \text{ mol/L NaOH} \times 0.025 \text{ L} = 0.003 \text{ mol NaOH}$$

$$\text{HF} + \text{NaOH} \rightarrow \text{NaF} + \text{H}_2\text{O}$$

I:	0.0105	0.003	0	0
Δ:	-0.003	-0.003	0.003	0
F:	0.0075	0	0.003	0

7. The standard free energy of formation of _____ is zero.

b

- (a) $\text{PF}_3(\text{g})$
- (b) $\text{H}_2(\text{g})$
- (c) $\text{FeS}(\text{s})$
- (a) $\text{Hg}(\text{g})$

$$\text{HF} \rightleftharpoons \text{H}^+ + \text{F}^-$$

I:	0.0075 mol / 0.0905 L	0	0.003 mol / 0.0905 L
Δ:	-x	+x	+x

Eg.

$$K_a = \frac{(x) \left(\frac{0.003}{0.0905}\right)}{\left(\frac{0.0075}{0.0905}\right)}$$

$$x = [\text{H}^+] = \text{pH} =$$

8. With thermodynamics, one cannot determine _____.

a

- (a) the speed of a reaction
- (b) the direction of a reaction
- (c) in which direction the reaction is spontaneous
- (d) the temperature at which a reaction will be spontaneous

9. Select the substance that is thought to be partially responsible for depleting the concentration of ozone in the stratosphere.

b

- (a) CO_2
- (b) CFCl_3
- (c) O_2
- (d) N_2

10. If ΔG is negative, a reaction is spontaneous in the forward direction. A reaction that is not spontaneous at low temperatures can become spontaneous at high temperature if ΔH is _____ and ΔS is _____.

- a
- (a) +,+
 - (b) -,-
 - (c) +,-
 - (d) -,+

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

11. What is the molarity of an acetic acid ($\text{HC}_2\text{H}_3\text{O}_2$) solution if 25.5 mL of this solution required 37.5 mL of 0.175 M NaOH to reach the equivalence point?

- a
- (a) 0.257
 - (b) 0.365
 - (c) 0.119
 - (d) 0.175
- $0.175 \frac{\text{mol}}{\text{L}} \text{NaOH} \times 0.0375 \text{ L} = 6.56 \times 10^{-3} \text{ mol}$
 * At eq. pt. an equal ^{molar} amt of acetic acid would be present

12. Given the following table of K_{sp} values, determine which compound listed has the greatest solubility.

Compound	K_{sp}
CdCO_3	5.2×10^{-12}
Cd(OH)_2	2.5×10^{-14}
AgI	8.3×10^{-17}
CuBr	5.3×10^{-9}

a

$$[\text{HC}_2\text{H}_3\text{O}_2] = \frac{0.00656 \text{ M}}{0.02552} = 0.257 \text{ M}$$

- (a) CuBr
- (b) CdCO_3
- (c) Cd(OH)_2
- (d) AgI

13. Carbon dioxide contributes to atmospheric warming by _____.

- b
- (a) absorbing incoming radiation from the sun and converting it to heat
 - (b) absorbing radiation emitted from the surface of the earth preventing its loss to space
 - (c) undergoing exothermic reactions extensively in the atmosphere
 - (d) reducing the concentration of CO in the atmosphere

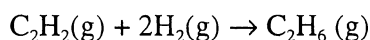
14. A solution containing which one of the following pairs of substances will be a buffer solution?

- d
- (a) NaI, HI
 - (b) KBr, HBr
 - (c) RbCl, HCl
 - (d) CsF, HF

15. Consider the following table of thermodynamic data. All values are tabulated for 25 °C (298 K).

Substance	ΔG_f° (kJ/mol)	S° (J/mol·K)
$C_2H_2(g)$	209	201
$C_2H_4(g)$	68	219
$C_2H_6(g)$	-33	230
$H_2O(g)$	-229	189
$C_2H_5OH(l)$	-175	161

The value of ΔS° for the following reaction is -233 J/K at 25 °C.



What is the standard entropy (S°) of $H_2(g)$ at 25 °C (in J/mol·K)?

$$-233 \text{ J/K} = 230 - (2(S^\circ_{H_2}) + 201)$$

$$-463 \text{ J/K} = -2(S^\circ_{H_2}) - 201$$

- (a) 204
 (b) 102
 (c) 131
 (d) 262

C

16. Of the following, which is the strongest acid?

- (a) H_2SeO_3
 (b) H_2SO_3
 (c) H_2SO_4
 (d) H_2SeO_4

Ans
 C

17. In which of the following aqueous solutions would you expect AgBr to have the highest solubility?

- (a) 0.10 M LiBr
 (b) 0.10 M $AgNO_3$
 (c) 0.20 M NaBr
 (d) pure water

d

18. What is the solubility (in M) of $PbCl_2$ in a 0.15 M solution of HCl? ($K_{sp} PbCl_2 = 1.6 \times 10^{-5}$)

$$1.6 \times 10^{-5} = [Pb^{2+}][Cl^-]^2$$

$$1.6 \times 10^{-5} = [Pb^{2+}][0.15]^2$$

$$[Pb^{2+}] = \text{solubility of } PbCl_2 = 7.11 \times 10^{-4}$$

- (a) 1.1×10^{-4}
 (b) 1.6×10^{-5}
 (c) 7.1×10^{-4}
 (d) 1.8×10^{-4}

C

19. Which one of the following is a source of carbon dioxide in the troposphere?

C

- (a) natural gas seepage
- (b) electrical discharges
- (c) fossil-fuel combustion
- (d) volcanic gases

20. For a reaction to be spontaneous at all temperatures, the signs of ΔH° and ΔS° must be _____ and _____ respectively.

C

- (a) +, +
- (b) +, -
- (c) -, +
- (d) -, -

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

21. Which below best describe(s) the behavior of an amphoteric hydroxide in water?

d

- (a) with both conc. aq. NaOH and conc aq. HCl, its clear solution forms a precipitate
- (b) with conc. aq. HCl, its suspension dissolves
- (c) with conc. aq. NaOH, its suspension dissolves
- (d) with both conc. aq. NaOH and conc. aq. HCl, its suspension dissolves

22. An initial pH of 4.00, an equivalence point at pH 9.35, and a moderately short, nearly vertical middle section correspond to a titration curve for _____.

C

- (a) strong acid titrated by strong base
- (b) strong base titrated by strong acid
- (c) weak acid titrated by strong base
- (d) weak acid titrated by weak base

23. Consider the titration of 25.0 mL of 0.723 M HClO_4 with 0.273 M KOH. The H^+ concentration after addition of 66.2 mL of KOH is _____ M.

b

- (a) 0.439
- (b) 1.0×10^{-7}
- (c) 0.723
- (d) 2.79×10^{-13}

$$0.723 \frac{\text{mol}}{\text{L}} \text{HClO}_4 \times 0.025 \text{L} = 0.018 \text{ mol HClO}_4$$

$$0.273 \frac{\text{mol}}{\text{L}} \text{KOH} \times 0.0662 \text{L} = 0.018 \text{ mol KOH}$$

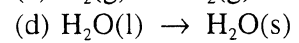
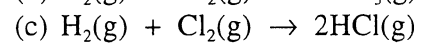
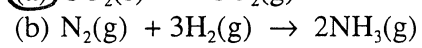
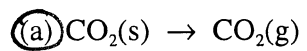
24. Which one of the following cannot act as a Lewis base?

C

- (a) Cl^-
- (b) NH_3
- (c) BF_3
- (d) CN^-

25. Of the processes below, which one is accompanied by a large increase in entropy?

a



PERIODIC TABLE OF THE ELEMENTS

Main groups		Transition metals										Main groups													
1A ^a												8A													
1	2A											3A	4A	5A	6A	7A	8A								
1 H 1.00794	2 He 4.002602											13 Al 10.811	14 Si 12.0107	15 P 14.00674	16 S 15.9994	17 Cl 18.998403	18 Ar 20.1797								
3 Li 6.941	4 Be 9.012182											13 Al 26.981538	14 Si 28.0855	15 P 30.973762	16 S 32.066	17 Cl 35.4527	18 Ar 39.948								
11 Na 22.989770	12 Mg 24.3050	3B	4B	5B	6B	7B	8B	9B	10B	11B	12B	31 Ga 69.723	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.904	36 Kr 83.80								
19 K 39.0983	20 Ca 40.078	21 Sc 44.95591	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938049	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6934	29 Cu 63.546	30 Zn 65.39	49 In 69.723	50 Sn 72.61	51 Sb 74.92160	52 Te 78.96	53 I 79.904	54 Xe 83.80								
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc [98]	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.411	81 Tl 114.818	82 Pb 118.710	83 Bi 121.760	84 Po 127.60	85 At [126.90447]	86 Rn 131.29								
55 Cs 132.90545	56 Ba 137.327	57 *La 138.90555	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.96655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.98038	84 Po [210]	85 At [210]	86 Rn [222]								
87 Fr [223]	88 Ra [226]	89 †Ac [227]	104 Rf [261]	105 Db [262]	106 Sg [266]	107 Bh [264]	108 Hs [265]	109 Mt [268]	110 Ds [269]	111 Nh [272]	112 Fl [277]	113 Mc [281]	114 Lv [285]	115 Ts [289]	116 Og [289]	117 Uue [293]	118 Uuq [293]								
												58 Ce 140.116	59 Pr 140.90765	60 Nd 144.24	61 Pm [145]	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.50	67 Ho 164.93032	68 Er 167.26	69 Tm 168.93421	70 Yb 173.04	71 Lu 174.967
												90 Th 232.0381	91 Pa 231.03588	92 U 238.0289	93 Np [237]	94 Pu [244]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]	103 Lr [262]

^aThe labels on top (1A, 2A, etc.) are common American usage. The labels below these (1, 2, etc.) are those recommended by the International Union of Pure and Applied Chemistry.
 The names and symbols for elements 110 and above have not yet been decided.
 Atomic weights in brackets are the masses of the longest-lived or most important isotope of radioactive elements.
 Further information is available at <http://www.srnl.ac.uk/chemistry/web-elements/>
 The production of elements 116 and 118 was reported in May 1999 by scientists at Lawrence Berkeley National Laboratory.