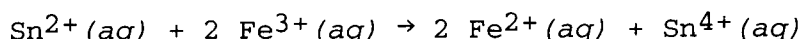




1. Given the following information

Half-reaction	$\epsilon_{\text{red}}^\circ$
$\text{Sn}^{4+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Sn}^{2+}(\text{aq})$	+0.154 V
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$	-0.440
$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{s})$	+0.771
$\text{Cr}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Cr}(\text{s})$	-0.74

determine the standard potential (in V) of a cell based on the reaction:



- a. +0.46
b. +0.62
c. +1.39
d. -0.46
e. +1.21
2. A reaction that is spontaneous, _____.
- 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
e. will occur very slowly
3. Given the following table of thermodynamic data,

substance	ΔH_f°	S°
$\text{PCl}_3(\text{g})$	-288.07 kJ/mol	311.7 J/mol-K
$\text{PCl}_3(\text{l})$	-319.6	217

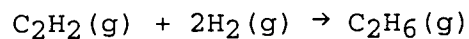
determine the normal boiling point (in °C) of PCl_3 .

- a. 3.00
b. 333
c. 273
d. 0.333
e. 59.9
4. How many grams of copper will be plated out by a current of 2.3 A applied for 25 minutes to a 0.50-M solution of copper(II) sulfate?
- a. 1.8×10^{-2}
b. 2.2
c. 1.1
d. 0.036
e. 0.019

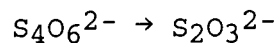
5. Consider the following table of thermodynamic data. All values are tabulated for 25°C.

Substance	ΔG°_f (kJ/mol)	S° (J/mol·K)
C ₂ H ₂ (g)	209	201
C ₂ H ₄ (g)	68	219
C ₂ H ₆ (g)	-33	230
H ₂ (g)	0	131
H ₂ O(g)	-229	189
C ₂ H ₅ OH(l)	-175	161

What is the value of ΔH° (in kJ) for the reaction described below?
Assume the reaction is performed at 25°C.



- a. -173
 - b. 236
 - c. -311
 - d. -248
 - e. 149
6. How many electrons are involved in the following half-reaction when it is balanced?

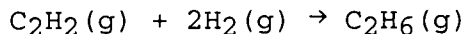


- a. 6
- b. 2
- c. 4
- d. 1
- e. 3

7. Consider the following table of thermodynamic data. All values are tabulated for 25°C.

Substance	ΔG°_f (kJ/mol)	S° (J/mol·K)
C ₂ H ₂ (g)	209	201
C ₂ H ₄ (g)	68	219
C ₂ H ₆ (g)	-33	230
H ₂ O(g)	-229	189
C ₂ H ₅ OH(l)	-175	161

The value of ΔS° for the following reaction is -233 J/K at 25°C. What is the standard entropy of H₂(g) at 25°C?



- a. 131
b. 204
c. 102
d. 262
e. 111
8. Consider the following reaction at 25°C.
- $$\text{C}(\text{s}) + \text{H}_2\text{O}(\text{g}) \rightarrow \text{CO}(\text{g}) + \text{H}_2(\text{g})$$
- $\Delta G^\circ = 91.2 \text{ kJ}$ $\Delta H^\circ = 131.4 \text{ kJ}$
- What is the value of ΔS° (J/K) for this reaction at 25°C?
- a. -135
b. 1.6
c. -1.6
d. 135
e. 223
9. Which substance is serving as the reducing agent in the following reaction?
- $$\text{Fe}_2\text{S}_3 + 12\text{HNO}_3 \rightarrow 2\text{Fe}(\text{NO}_3)_3 + 3\text{S} + 6\text{NO}_2 + 6\text{H}_2\text{O}$$
- a. HNO₃
b. S
c. NO₂
d. Fe₂S₃
e. H₂O

10. With thermodynamics, one cannot determine _____.
- the speed of a reaction
 - the direction of a reaction
 - the extent of a reaction
 - in which direction a reaction is spontaneous
 - the temperature at which a reaction will be spontaneous
11. How many minutes will it take to plate out 2.19 g of chromium metal from a solution of Cr^{3+} using a current of 35.2 amps?
- 5.77
 - 346
 - 115
 - 1.92
 - 17.3

12. Bromine can oxidize each of the metals below except

<u>Substance</u>	<u>E° (v)</u>
Br_2	1.09
Ag	0.80
Pt	1.20
Cu	0.34
Pd	0.83
Li	-3.05

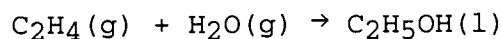
- Ag
 - Pt
 - Cu
 - Pd
 - Li
13. The standard reduction potentials in V for Zn^{2+} and Cu^{2+} are -0.76 and +0.34, respectively. What is the potential of the cell (in V) represented below?



- 1.14
 - 0.42
 - +1.07
 - +1.10
 - +0.42
14. The equilibrium constant for a reaction is 0.48 at 25°C . What is the value of ΔG° (kJ) at this temperature? ($R = 8.314 \text{ J/K}\cdot\text{mol}$)
- 1.8
 - 4.2
 - 1.5×10^2
 - 4.2
 - More information is needed.

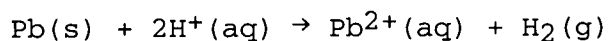
15. ΔS° will be positive for the reaction _____.
- $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g})$
 - $2\text{NO}_2(\text{g}) \rightarrow \text{N}_2\text{O}_4(\text{g})$
 - $\text{H}^+(\text{aq}) + \text{F}^-(\text{aq}) \rightarrow \text{HF}(\text{aq})$
 - $\text{BaF}_2(\text{s}) \rightarrow \text{Ba}^{2+}(\text{aq}) + 2\text{F}^-(\text{aq})$
 - $2\text{Hg}(\text{l}) + \text{O}_2(\text{g}) \rightarrow 2\text{HgO}(\text{s})$
16. Which one of the following types of elements is most likely to be good oxidizing agents?
- alkali metals
 - lanthanides
 - alkaline earth elements
 - transition elements
 - halogens

17. Determine the value of ΔG° (kJ) for the following reaction at 25°C :



Substance	ΔG°_f (kJ/mol)	S° (J/mol·K)
$\text{C}_2\text{H}_2(\text{g})$	209	201
$\text{C}_2\text{H}_4(\text{g})$	68	219
$\text{C}_2\text{H}_6(\text{g})$	-33	230
$\text{H}_2(\text{g})$	0	131
$\text{H}_2\text{O}(\text{g})$	-229	189
$\text{C}_2\text{H}_5\text{OH}(\text{l})$	-175	161

- 122
 - 472
 - 122
 - 14
 - 175
18. E° for the following reaction is 0.13 V. What is the value of ΔG° (in kJ) for the reaction? ($F = 96,500 \text{ J/V}\cdot\text{mol}$)



- 25
- 25
- 12
- 12
- 50

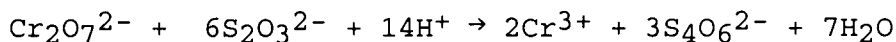
19. Consider the reaction: $\text{NH}_3(\text{g}) + \text{HCl}(\text{g}) \rightarrow \text{NH}_4\text{Cl}(\text{s})$

Given the following table of thermodynamic data,

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

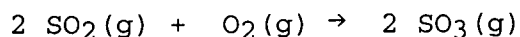
determine the value of K for the reaction at 25°C.

- a. 150
 - b. 9.3×10^{15}
 - c. 8.4×10^4
 - d. 1.1×10^{-16}
 - e. 1.4×10^8
20. _____ is the oxidizing agent in the reaction below.



- a. $\text{Cr}_2\text{O}_7^{2-}$
 - b. $\text{S}_2\text{O}_3^{2-}$
 - c. H^+
 - d. Cr^{3+}
 - e. $\text{S}_4\text{O}_6^{2-}$
21. The process of _____ causes a decrease in the entropy of the system.
- a. boiling water to form steam
 - b. dissolution of solid KCl in water
 - c. mixing of two gases into one container
 - d. freezing water to form ice
 - e. melting ice to form water
22. When ammonium chloride dissolves in water the temperature of the solution is less than that of the original water sample. Thus, we know that ΔH is _____ and that ΔS is _____.
- a. negative, negative
 - b. positive, positive
 - c. negative, positive
 - d. positive, negative
 - e. negative, zero

23. The standard free energy change for the reaction below at 25°C is _____ kJ.



Substance	ΔH_f° (kJ/mol)	S° (J/mol·K)
SO ₂ (g)	-297	249
O ₂ (g)	0	205
SO ₃ (g)	-395	256

- a. -196
- b. -191
- c. -5
- d. -139
- e. More data is needed.

24. Given the following information

Half-reaction	$\epsilon_{\text{red}}^\circ$
$\text{Sn}^{4+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Sn}^{2+}(\text{aq})$	+0.154 V
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$	-0.440
$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{s})$	+0.771
$\text{Cr}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Cr}(\text{s})$	-0.74

which of the following reactions will occur spontaneously as written?

- a. $3 \text{Fe}^{3+}(\text{aq}) + \text{Cr}^{3+}(\text{aq}) \rightarrow \text{Cr}(\text{s}) + 3 \text{Fe}^{3+}(\text{aq})$
- b. $2 \text{Cr}^{3+}(\text{aq}) + 3 \text{Sn}^{2+}(\text{aq}) \rightarrow 3 \text{Sn}^{4+}(\text{aq}) + 2 \text{Cr}(\text{s})$
- c. $\text{Sn}^{4+}(\text{aq}) + \text{Fe}^{2+}(\text{aq}) \rightarrow \text{Sn}^{2+}(\text{aq}) + \text{Fe}(\text{s})$
- d. $\text{Sn}^{2+}(\text{aq}) + \text{Fe}^{2+}(\text{aq}) \rightarrow \text{Sn}^{4+}(\text{aq}) + \text{Fe}^{3+}(\text{aq})$
- e. $2 \text{Cr}(\text{s}) + 3 \text{Fe}^{2+}(\text{aq}) \rightarrow 3 \text{Fe}(\text{s}) + 2 \text{Cr}^{3+}(\text{aq})$

25. Calculate ΔS° for the reaction $2\text{C}(\text{diamond}) + \text{O}_2(\text{g}) \rightarrow 2\text{CO}(\text{g})$ at 25°C, given that S° at 25°C for O₂(g), CO(g) and diamond are 205.0-, 197.9-, and 2.43-J/K-mol, respectively.

- a. -185.9
- b. +185.9
- c. -9.5
- d. +9.5
- e. -195.7



1. b
2. b
3. e
4. c
5. c
6. b
7. a
8. d
9. d
10. a
11. a
12. b
13. c
14. a
15. d
16. e
17. d
18. a
19. b
20. ~~b~~ a
21. d
22. b
23. d
24. e
25. b