Chapter 19
Name_____

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

Use the table below to answer the questions that follow.

Thermodynamic Quantities for Selected Substances at 298.15 K (25°C)

Substance	ΔH°f (kJ/mol)	ΔG°f (kJ/mol)	S (J/K–mol)
Carbon			
C (s, diamond)	1.88	2.84	2.43
C (s, graphite)	0	0	5.69
C_2H_2 (g)	226.7	209.2	200.8
C_2H_4 (g)	52.30	68.11	219.4
C_2H_4 (g)	–84.68	–32.89	229.5
CO (g)	–110.5	–137.2	197.9
CO_2 (g)	–393.5	–394.4	213.6
Hydrogen			
H_2(g)	0	0	130.58
Oxygen			
O_2 (g)	0	0	205.0
H_2O (l)	–285.83	–237.13	69.91

1) The value of ΔS° for the catalytic hydrogenation of acetylene to ethene, 1) _____

$$C_2H_2\,(g) + H_2\,(g) \rightarrow C_2H_4\,(g)$$

is _____ J/K.

A) –18.6 B) –112.0 C) +550.8 D) +112.0 E) +18.6

2) The combustion of acetylene in the presence of excess oxygen yields carbon dioxide and water: 2) _____

$$2C_2H_2\,(g) + 5O_2\,(g) \rightarrow 4CO_2\,(g) + 2H_2O\,(l)$$

The value of ΔS^o for this reaction is _____ J/K.

A) –122.3 B) +689.3 C) +122.3 D) +432.4 E) –432.4

3) The value of $\Delta S°$ for the reaction 3) _____

$$2C\ (s,\ diamond) + O_2\ (g) \rightarrow 2CO\ (g)$$

is _____ J/K.

A) –195.7 B) +185.9 C) –185.9 D) +9.5 E) –9.5

4) The value of $\Delta S°$ for the catalytic hydrogenation of ethene to ethane, 4) _____

$$C_2H_4\ (g) + H_2(g) \rightarrow C_2H_6\ (g)$$

is _____ J/K.

A) –120.5 B) +101.9 C) –232.5 D) +112.0 E) –101.9

5) The value of $\Delta S°$ for the catalytic hydrogenation of acetylene to ethane, 5) _____

$$C_2H_2\ (g) + 2H_2\ (g) \rightarrow C_2H_6\ (g)$$

is _____ J/K.

A) –76.0 B) +440.9 C) +28.7 D) –232.5 E) +232.5

6) The value of $\Delta S°$ for the oxidation of carbon to carbon monoxide, 6) _____

$$2C\ (s,\ graphite) + O_2\ (g) \rightarrow 2CO\ (g)$$

is _____ J/K. Carbon monoxide is produced in the combustion of carbon with limited oxygen.

A) –408.6 B) –12.8 C) +395.8 D) +179.4 E) +408.6

7) The value of $\Delta S°$ for the oxidation of carbon to carbon dioxide, 7) _____

$$C\ (s,\ graphite) + O_2\ (g) \rightarrow CO_2(g)$$

is _____ J/K. The combustion of carbon, as in charcoal briquettes, in the presence of abundant oxygen produces carbon dioxide.

A) +424.3 B) +2.9 C) –205.0 D) –2.9 E) +205.0

8) The combustion of ethene in the presence of excess oxygen yields carbon dioxide and water: 8) _____

$$C_2H_4\ (g) + 3O_2\ (g) \rightarrow 2CO_2\ (g) + 2H_2O\ (l)$$

The value of ΔS^o for this reaction is _____ J/K.

A) –267.4 B) +140.9 C) –140.9 D) –347.6 E) +347.6

9) The combustion of ethane in the presence of excess oxygen yields carbon dioxide and water: 9) _____

$$2C_2H6\,(g) + 7O_2\,(g) \rightarrow 4CO_2\,(g) + 6H_2O\,(l)$$

The value of ΔS^o for this reaction is _____ J/K.

A) –718.0 B) +151.0 C) –151.0 D) –620.9 E) +718.0

10) The combustion of hydrogen in the presence of excess oxygen yields water: 10) _____

$$2H_2(g) + O_2(g) \rightarrow 2H_2O\,(l)$$

The value of ΔS^o for this reaction is _____ J/K.

A) –265.7 B) –405.5 C) +405.5 D) +265.7 E) –326.3

Use the table below to answer the questions that follow.

Thermodynamic Quantities for Selected Substances at 298.15 K (25°C)

Substance	$\Delta H°_f$ (kJ/mol)	$\Delta G°_f$ (kJ/mol)	S (J/K–mol)
Calcium			
Ca (s)	0	0	41.4
$CaCl_2$ (s)	–795.8	–748.1	104.6
Ca_2^+ (aq)	226.7	209.2	200.8
Chlorine			
Cl_2 (g)	0	0	222.96
Cl– (aq)	–167.2	–131.2	56.5
Oxygen			
O_2 (g)	0	0	205.0
H_2O (l)	–285.83	–237.13	69.91
Phosphorus			
P_2 (g)	144.3	103.7	218.1
PCl_3 (g)	–288.1	–269.6	311.7
$POCl_3$ (g)	–542.2	–502.5	325
Sulfur			
S (s, rhombic)	0	0	31.88
SO_2(g)	–269.9	–300.4	248.5
SO_3(g)	–395.2	–370.4	256.2

11) The value of $\Delta S°$ for the oxidation of solid elemental sulfur to gaseous sulfur trioxide, 11) _____

$$2S\ (s, \text{rhombic}) + 3O_2(g) \rightarrow 2SO_3\ (g)$$

is _____ J/K.

A) –19.3 B) –166.4 C) +493.1 D) +19.3 E) –493.1

12) The value of $\Delta S°$ for the oxidation of solid elemental sulfur to gaseous sulfur dioxide, 12) _____

$$S\ (s, \text{rhombic}) + O_2(g) \rightarrow SO_2(g)$$

is _____ J/K.

A) –11.6 B) –248.5 C) +248.5 D) +11.6 E) +485.4

13) The value of ΔS° for the decomposition of gaseous sulfur trioxide to solid elemental sulfur and gaseous oxygen, 13) _____

$$2SO_3\ (g) \rightarrow 2S\ (s, \text{rhombic}) + 3O_2\ (g)$$

is _____ J/K.

A) +166.4 B) +19.3 C) +493.1 D) −493.1 E) −19.3

14) The value of ΔS° for the decomposition of gaseous sulfur dioxide to solid elemental sulfur and gaseous oxygen, 14) _____

$$SO_2\ (g) \rightarrow S\ (s, \text{rhombic}) + O_2\ (g)$$

is _____ J/K.

A) −248.5 B) −11.6 C) +248.5 D) +485.4 E) +11.6

15) The value of ΔS° for the formation of $POCl_3$ from its constituent elements, 15) _____

$$P_2\ (g) + O_2\ (g) + 3Cl_2\ (g) \rightarrow 2POCl_3\ (g)$$

is _____ J/K.

A) +771 B) +321 C) −771 D) −442 E) −321

16) The value of ΔS° for the decomposition of $POCl_3$ into its constituent elements, 16) _____

$$2POCl_3\ (g) \rightarrow P_2\ (g) + O_2\ (g) + 3Cl_2\ (g)$$

is _____ J/K.

A) +321 B) +771 C) +442 D) −771 E) −321

17) The value of ΔS° for the formation of phosphorous trichloride from its constituent elements, 17) _____

$$P_2\ (g) + 3Cl_2\ (g) \rightarrow 2PCl_3\ (g)$$

is _____ J/K.

A) +129.4 B) +311.7 C) −129.4 D) −311.7 E) −263.7

18) The value of ΔS° for the decomposition of phosphorous trichloride into its constituent elements, 18) _____

$$2PCl_3\ (g) \rightarrow P_2\ (g) + 3Cl_2(\ g)$$

is _____ J/K.

A) +311.7 B) −129.4 C) +263.7 D) +129.4 E) −311.7

19) The value of $\Delta S°$ for the formation of calcium chloride from its constituent elements, 19) _____

$$Ca\ (s) + Cl_2\ (g) \rightarrow CaCl_2\ (s)$$

is _____ J/K.

A) +104.6 B) +369.0 C) –104.6 D) +159.8 E) –159.8

20) The value of $\Delta S°$ for the decomposition of calcium chloride into its constituent elements, 20) _____

$$CaCl_2\ (s) \rightarrow Ca\ (s) + Cl_2\ (g)$$

is _____ J/K.

A) +104.6 B) +159.8 C) +369.0 D) –104.6 E) –159.8

21) The value of $\Delta H°$ for the oxidation of solid elemental sulfur to gaseous sulfur trioxide, 21) _____

$$2S\ (s, rhombic) + 3O_2(\ g) \rightarrow 2SO_3\ (g)$$

is _____ kJ/mol.

A) +790.4 B) –790.4 C) +105.1 D) –395.2 E) +395.2

22) The value of $\Delta H°$ for the decomposition of gaseous sulfur trioxide to its component elements, 22) _____

$$2SO_3\ (g) \rightarrow 2S\ (s, rhombic) + 3O_2\ (g)$$

is _____ kJ/mol.

A) +395.2 B) –395.2 C) –790.4 D) +105.1 E) +790.4

23) The value of $\Delta H°$ for the oxidation of solid elemental sulfur to gaseous sulfur dioxide, 23) _____

$$S\ (s, rhombic) + O_2\ (g) \rightarrow SO_2\ (g)$$

is _____ kJ/mol.

A) +11.6 B) –269.9 C) +269.9 D) +0.00 E) –11.6

24) The value of $\Delta H°$ for the decomposition of gaseous sulfur dioxide to solid elemental sulfur and gaseous oxygen, 24) _____

$$SO_2\ (g) \rightarrow S\ (s\ ,rhombic) + O_2\ (g)$$

is _____ kJ/mol.

A) +135.0 B) +0.0 C) –135.90 D) +269.9 E) –269.9

25) The value of $\Delta H°$ for the formation of $POCl_3$ from its constituent elements, 25) _____

$$P_2\,(g) + O_2\,(g) + 3Cl_2\,(g) \rightarrow 2POCl_3\,(g)$$

is _____ kJ/mol.

A) –397.7 B) –1228.7 C) –686.5 D) +686.5 E) +1228.7

26) The value of $\Delta H°$ for the decomposition of $POCl_3$ into its constituent elements, 26) _____

$$2POCl_3\,(g) \rightarrow P_2\,(g) + O_2\,(g) + 3Cl_2\,(g)$$

is _____ kJ/mol.

A) –940.1 B) –1,228.7 C) +0.00 D) +1,228.7 E) +940.1

27) The value of $\Delta H°$ for the formation of phosphorous trichloride from its constituent elements, 27) _____

$$P_2\,(g) + 3Cl_2\,(g) \rightarrow 2PCl_3\,(g)$$

is _____ kJ/mol

A) +432.4 B) –720.5 C) –432.4 D) –288.1 E) +720.5

28) The value of $\Delta H°$ for the decomposition of phosphorous trichloride into its constituent elements, 28) _____

$$2PCl_3\,(g) \rightarrow P_2\,(g) + 3Cl_2\,(g)$$

is _____ kJ/mol.

A) –288.1 B) +720.5 C) +288.1 D) +576.2 E) –720.5

29) The value of $\Delta H°$ for the formation of calcium chloride from its constituent elements, 29) _____

$$Ca\,(s) + Cl_2\,(g) \rightarrow CaCl_2\,(s)$$

is _____ kJ/mol.

A) +397.9 B) +795.8 C) –795.8 D) –397.9 E) +0.00

30) The value of $\Delta H°$ for the decomposition of calcium chloride into its constituent elements, 30) _____

$$CaCl_2\,(s) \rightarrow Ca\,(s) + Cl_2\,(g)$$

is _____ kJ/mol.

A) –397.9 B) +397.9 C) +795.8 D) –795.8 E) –0.00

31) The value of ΔG° at 25 °C for the oxidation of solid elemental sulfur to gaseous sulfur trioxide, 31) _____

$$2S\ (s\ ,rhombic)\ +\ 3O_2\ (g)\ \rightarrow 2SO_3\ (g)$$

is _____ kJ/mol.

A) +185.2 B) +740.8 C) +370.4 D) −740.8 E) −370.4

32) The value of ΔG° at 25 °C for the oxidation of solid elemental sulfur to gaseous sulfur dioxide, 32) _____

$$S\ (s,\ rhombic)\ +\ O_2(g)\ \rightarrow\ SO_2\ (g)$$

is _____ kJ/mol.

A) −300.4 B) −269.9 C) +300.4 D) +269.9 E) +395.2

33) The value of ΔG° at 25 °C for the decomposition of gaseous sulfur trioxide to solid elemental sulfur and gaseous oxygen, 33) _____

$$2SO_3\ (g)\ \rightarrow\ 2S\ (s,\ rhombic)\ +\ 3O_2\ (g)$$

is _____ kJ/mol.

A) +740.8 B) −740.8 C) −370.4 D) +185.2 E) +370.4

34) The value of ΔG° at 25 °C for the decomposition of gaseous sulfur dioxide to solid elemental sulfur and gaseous oxygen, 34) _____

$$SO_2\ (g)\ \rightarrow\ S\ (s,\ rhombic)\ +\ O_2\ (g)$$

is _____ kJ/mol.

A) −300.4 B) +395.2 C) +269.9 D) −269.9 E) +300.4

35) The value of ΔG° at 25 °C for the formation of $POCl_3$ from its constituent elements, 35) _____

$$P_2\ (g)\ +\ O_2\ (g)\ +\ 3Cl_2\ (g)\ \rightarrow 2POCl_3\ (g)$$

is _____ kJ/mol.

A) +606.2 B) −606.2 C) +1,109 D) −1,005 E) −1,109

36) The value of ΔG° at 25 °C for the decomposition of $POCl_3$ into its constituent elements, 36) _____

$$2POCl_3\ (g)\ \rightarrow\ P_2\ (g)\ +\ O_2\ (g)\ +\ 3Cl_2\ (g)$$

is _____ kJ/mol.

A) −606.2 B) +1,109 C) −1,005 D) +606.2 E) −1,109

37) The value of $\Delta G°$ at 25 °C for the formation of phosphorous trichloride from its constituent elements, 37) _____

$$P_2\,(g) + 3Cl_2\,(g) \rightarrow 2PCl_3\,(g)$$

is _____ kJ/mol.

A) –373.3 B) +539.2 C) +642.9 D) –539.2 E) –642.9

38) The value of $\Delta G°$ at 25 °C for the decomposition of phosphorous trichloride into its constituent elements, 38) _____

$$2PCl_3\,(g) \rightarrow P_2\,(g) + 3Cl_2\,(g)$$

is _____ kJ/mol.

A) +539.2 B) –642.9 C) +642.9 D) –539.2 E) –373.3

39) The value of $\Delta G°$ at 25 °C for the formation of calcium chloride from its constituent elements, 39) _____

$$Ca\,(s) + Cl_2\,(g) \rightarrow CaCl_2\,(s)$$

is _____ kJ/mol.

A) –795.8 B) +763.7 C) +795.8 D) –748.1 E) +748.1

40) The value of $\Delta G°$ at 25 °C for the decomposition of calcium chloride into its constituent elements, 40) _____

$$CaCl_2\,(s) \rightarrow Ca\,(s) + Cl_2\,(g)$$

is _____ kJ/mol.

A) –748.1 B) –795.8 C) +763.7 D) +748.1 E) +795.8

41) The value of $\Delta G°$ at 373 °K for the oxidation of solid elemental sulfur to gaseous sulfur dioxide, 41) _____

$$S\,(s, \text{rhombic}) + O_2\,(g) \rightarrow SO_2\,(g)$$

is _____ kJ/mol. At 298K, $\Delta H°$ for this reaction is –269.9 kJ/mol, and $\Delta S°$ is +11.6 J/K.

A) –300.4 B) +300.4 C) –4,597 D) –274.2 E) +4,597

Use the table below to answer the questions that follow.

Thermodynamic Quantities for Selected Substances at 298.15 K (25°C)

Substance	$\Delta H°_f$ (kJ/mol)	$\Delta G°_f$ (kJ/mol)	S (J/K–mol)
Calcium			
Ca (s)	0	0	41.4
$CaCl_2$ (s)	–795.8	–748.1	104.6
Ca_2^+ (aq)	226.7	209.2	200.8
Chlorine			
Cl_2 (g)	0	0	222.96
Cl– (aq)	–167.2	–131.2	56.5
Oxygen			
O_2 (g)	0	0	205.0
H_2O (l)	–285.83	–237.13	69.91
Phosphorus			
P_2 (g)	144.3	103.7	218.1
PCl_3 (g)	–288.1	–269.6	311.7
$POCl_3$ (g)	–542.2	–502.5	325
Sulfur			
S (s, rhombic)	0	0	31.88
SO_2(g)	–269.9	–300.4	248.5
SO_3(g)	–395.2	–370.4	256.2

42) The value of $\Delta G°$ at 373 K for the oxidation of solid elemental sulfur to gaseous sulfur trioxide, 42) _____

$$2S\ (s, \text{rhombic}) + 3O_2\ (g) \rightarrow 2SO_3\ (g)$$

is _____ kJ/mol.

A) –61.3 B) –740.8 C) –728.3 D) +61.3 E) +740.8

43) Given the thermodynamic data in the table below, calculate the equilibrium constant for the reaction: 43) _____

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

Substance	$\Delta H_f°$ (kJ/mol)	$\Delta°$ (J/mol • K)
SO_2 (g)	–297	249
O_2 (g)	0	205
SO_3 (g)	–395	256

A) 3.82×10^{23}

B) 1.06

C) 1.95

D) 2.32×10^{24}

E) More data are needed.

44) The equilibrium constant for a reaction is 0.48 at 25 °C. What is the value of $\Delta G°$ (kJ/mol) at this temperature? 44) _____

A) –4.2

B) 4.2

C) 1.5×10^{2}

D) 1.8

E) More information is needed.

45) The equilibrium constant for the following reaction is 5.0×10^{8} at 25 °C. 45) _____

$$N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g)$$

The value of $\Delta G°$ for this reaction is _____ kJ/mol.

A) –4.2 B) –22 C) 22 D) –50 E) –25

46) Consider the reaction: 46) _____

$NH_3\ (g) + HCl\ (g) \rightarrow NH_4Cl\ (s)$

Given the following table of thermodynamic data at 298 °K:

Substance	$\Delta H_f°$ (kJ/mol)	S° (J/K • mol)
NH_3 (g)	–46.19	192.5
HCl (g)	–92.30	186.69
NH_4Cl (s)	–314.4	94.6

The value of K for the reaction at 25 °C is _____.

A) 1.4×10^{8}

B) 150

C) 9.3×10^{15}

D) 8.4×10^{4}

E) 1.1×10^{-16}

47) Consider the reaction: 47) _____

$FeO\ (s) + Fe\ (s) + O_2\ (g) \rightarrow Fe_2O_3\ (s)$

Given the following table of thermodynamic data at 298 °K:

Substance	$\Delta H_f°$ (kJ/mol)	S° (J/K • mol)
FeO (s)	–271.9	60.75
Fe (s)	0	27.15
O_2 (g)	0	205.0
Fe_2O_3 (s)	–822.16	89.96

The value K for the reaction at 25 °C is _____.

A) 5.9×10^{4}

B) 3.8×10^{-14}

C) 370

D) 8.1×10^{19}

E) 7.1×10^{85}

48) Consider the reaction: 48) _____

$$Ag^+ (aq) + Cl^- (aq) \rightarrow AgCl (s)$$

Given the following table of thermodynamic data at 298 °K:

Substance	$\Delta H_f°$ (kJ/mol)	S° (J/K• mol)
Ag^+ (aq)	105.90	73.93
Cl^- (aq)	–167.2	56.5
AgCl(s)	–127.0	96.11

The value of K for the reaction at 25 °C is _____.

A) 3.7×10^{10}

B) 810

C) 1.9×10^{-10}

D) 5.4×10^{9}

E) 1.8×10^{4}

Answer Key
Testname: CHAPTER 19 PRACTICE QUESTIONS

1) B
2) E
3) B
4) A
5) D
6) D
7) B
8) A
9) D
10) E
11) B
12) D
13) A
14) B
15) D
16) C
17) E
18) C
19) E
20) B
21) B
22) E
23) B
24) D
25) B
26) D
27) B
28) B
29) C
30) C
31) D
32) A
33) A
34) E
35) E
36) B
37) E
38) C
39) D
40) D
41) D
42) C
43) D
44) D
45) D
46) C
47) E
48) D