INTRODUCTION

E0.1 8.0×10^{2} N

E0.2 0.43%

E0.3 2.6 kJ

E0.4 36 J

E0.5 1.4×10^{2} kJ

E0.6 2.3 kJ

E0.7 2.483×10^{-24} J

E0.8 12 J

E0.9 (a) 1.602×10^{-19} J
(b) 96.47 kJ mol^{-1}

E0.10 (a) 2.4×10^{-19} J
(b) 1.4×10^{2} kJ mol^{-1}

E0.11 11.6 GJ

E0.12 (a) 810. Torr
(b) 0.962 atm
(c) 0.222 atm
(d) 1.03×10^{5} Pa

E0.13 1.24×10^{3} bar

E0.14 0.98 atm

E0.15 (a) 1.5×10^{3} Pa
(b) 5.6×10^{2} Pa

E0.16 Differ by as much as 1 part in 10^{6}

E0.17 (a) 9.80665 Pa
(b) 0.0735561 Torr

E0.18 –459.67°F

E0.19 (a) $\theta/°\mathrm{C} = 100 - \theta'/°\mathrm{C}'$
(b) $\theta_F/°\mathrm{F} = 212 - \frac{9}{5}\theta'/°\mathrm{C}'$

E0.20 $\theta_P/°\mathrm{P} = 7.092\times(\theta/°\mathrm{C} + 209.9)$
(a) $\theta_P/°\mathrm{P} = 7.092\times(T/\mathrm{K} - 63.25)$
(b) $\theta_P/°\mathrm{P} = 3.940\times(\theta_F/°\mathrm{F} + 345.8°\mathrm{F})$

E0.21 671.67°R

E0.22 3.3×10^{22} glucose molecules

E0.23 3.71×10^{24} octane molecules

E0.24 3.7×10^{19} myoglobin molecules

E0.25 $0.9\overline{7}$

E0.26 $\rho = M/V_m$

E0.27 73.0 mmol dm^{-3}

E0.28 17.5 g NaCl

E0.29 (a)
(i) Water: 17.5 g NaCl
(ii) Benzene: 9.02×10^{-2} mol dm^{-3}
(b)
(i) Water: 9.12×10^{-2} mol kg^{-1}
(ii) Benzene: 0.105 mol kg^{-1}

E0.32 9.574 mol kg^{-1}

E0.33 2.17 kg

E0.34 5.3×10^{2} kg

CHAPTER 1

The Properties of Gasses

E1.1 92.1 kPa

E1.2 2.25 kPa

E1.3 4.33 mmol

E1.4 665 bar

E1.5 10.0 atm

E1.6 4.18 bar

E1.7 173 kPa

E1.8 29.5 K

E1.9 394 K

E1.10 (a) 3.6 m^3
(b) 178 m^3

E1.11 0.50 m^3

E1.13 3.4×10^{8} dm^3

E1.14 6.7×10^{-2} atm .

E1.15 (a) 1.32 dm^3
(b) 61.2 kPa .

E1.16 713 Torr

E1.17 132 g mol^{-1}

E1.18 16.4 g mol^{-1} .

E1.19 (a) $p_{H_2} = 2.0$ bar, $p_{N_2} = 1.0$ bar
(b) 3.0 bar

E1.20 (a)

$\overline{c}_{He}(79\text{ K}) = 647\text{ m s}^{-1}$
$\overline{c}_{He}(315\text{ K}) = 1.29\text{ km s}^{-1}$
$\overline{c}_{He}(1500\text{ K}) = 2.82\text{ km s}^{-1}$

(b)

$\overline{c}_{CH_4}(79\text{ K}) = 323\text{ m s}^{-1}$
$\overline{c}_{CH_4}(315\text{ K}) = 645\text{ m s}^{-1}$
$\overline{c}_{CH_4}(1500\text{ K}) = 1.41\text{ km s}^{-1}$

E1.21 (a) 72 K
(b) $94\overline{4}$ m s^{-1}

E1.22 0.065 Pa

E1.23 2.4×10^{6} Pa

E1.24 0.97 μm

E1.25 (a) 5.3×10^{10} s^{-1}
(b) 5.3×10^{9} s^{-1}
(c) 5.3×10^{4} s^{-1}

E1.26 (a) 6.5×10^{33} s^{-1}
(b) 6.5×10^{31} s^{-1}
(c) 6.5×10^{21} s^{-1}

E1.27 4.5×10^{8} s^{-1}

E1.28 (a) 6.8 nm
(b) 68 nm
(c) 7 mm

E1.29 Independent of temperature

E1.30 (a)

(i) $10\overline{1}$ kPa
(ii) $83\overline{1}$ bar

(b)

(i) 0.99 atm
(ii) 1.8×10^{3} atm

E1.31 For a perfect gas: 55.6 atm
For a van der Waals gas: 43.0 atm

E1.32 $B = b - \frac{a}{RT}$ and $C = b^2$

E1.33 (a) 4.60×10^{-2} dm^3 mol^{-1}
(b) 0.66

E1.34 (a) 1.26 dm^6 atm mol^{-2}
(b) 3.46 × 10^{-2} $dm^3 mol^{-1}$

E1.35 1.03×10^3 K

CHAPTER 2
Thermodynamics: the First Law

E2.1 (a) −0.10 J
(b) −100. J

E2.2 −5.5 kJ

E2.3 (a) −99 J
(b) −167 J

E2.4 +123 J

E2.5 +2.99 kJ

E2.6 −1.25 kJ

E2.7 (a) 0
(b) −782 J

E2.8 -1.0×10^2 J

E2.9 23.7 J K^{-1}

E2.10 (a) 0.45 J K^{-1} g^{-1}
(b) 25 J K^{-1} mol^{-1}

E2.11 42 kJ

E2.12 8.7×10^4 J

E2.13 (a) 30 J K^{-1} mol^{-1}
(b) 38 J K^{-1} mol^{-1}

E2.14 (a) 9.2×10^2 kJ
(b) 6.1×10^2 s .

E2.15 773 J

E2.16 −25 kJ

E2.17 +1.86 kJ

E2.18 −14.54 J

E2.19 +42.5 J

E2.20 20 kJ .

E2.22 2.468kJ mol^{-1}

E2.23 (a) −1.2 kJ
(b) −1.2 kJ
(c) 80 J K^{-1}

E2.24 (a) +2.2 kJ
(b) +2.2 kJ
(c) +1.6 kJ

E2.25 20.83 J K^{-1} mol^{-1}

E2.26 (a) 641 J mol^{-1}
(b) 458 J mol^{-1}

CHAPTER 3
Thermodynamics:
Applications of the First Law

E3.1 6.91 mJ mol^{-1}

E3.2 $+2.83\times10^4$ kJ

E3.3 (a) $+2.44\times10^3$ kJ
(b) $+2.26\times10^3$ kJ

E3.4 +39.8 kJ mol^{-1}

E3.5 (a) +80.0 kJ
(b) −5.20 kJ
(c) +74.8 kJ

E3.7 +239 kJ

E3.8 +4.96 kJ mol^{-1}

E3.9 −2.48 kJ mol^{-1}

E3.10 +163 kJ

E3.11 (a) +354.8 kJ mol^{-1}
(b) +352.3 kJ mol^{-1}

E3.12 (a) 388 kJ mol^{-1}
(b) smaller.

E3.13 (a) 16 kJ mol^{-1}
(b) −3028 kJ mol^{-1}

E3.14 (a) −3.29 GJ
(b) −2.71 GJ

E3.15 (a) −1560 kJ mol^{-1}
(b) 51.88 kJ g^{-1}
(c) Ethane is a less efficient fuel

E3.16 −4564.7 kJ mol^{-1}

E3.17 −85 kJ mol^{-1}

E3.18 −432 kJ mol^{-1}

E3.19 +225 kJ mol^{-1}

E3.20 (a) 4.22 kJ K^{-1}
(b) 0.769 K

E3.21 (a) −2.80 MJ mol^{-1}
(b) −2.80 MJ mol^{-1}
(c) −1.27 MJ mol^{-1}

E3.22 (a) −1333 kJ mol^{-1} .
(b) −1331 kJ mol^{-1}
(c) −815 kJ mol^{-1}

E3.24 +112.27 kJ mol^{-1}

E3.25 −383 kJ mol^{-1}

E3.26 +1.9 kJ mol^{-1} .

E3.27 +30.6 kJ mol^{-1}

E3.28 (a) 37°C
(b) 4.1 kg

E3.29 (a) −2205 kJ mol^{-1}
(b) −2200 kJ mol^{-1}

E3.30 (a) exothermic, $\Delta_r H^{\ominus}$ = negative
(b) endothermic, $\Delta H^{\ominus}$ = positive
(c) endothermic, $\Delta_{vap} H^{\ominus}$ = positive
(d) endothermic, $\Delta_{fus} H^{\ominus}$ = positive
(e) endothermic, $\Delta_{sub} H^{\ominus}$ = positive

E3.31 (a) −57.20 kJ mol^{-1}
(b) −28.6 kJ mol^{-1}
(c) −138.2 kJ mol^{-1}
(d) −32.88 kJ mol^{-1}
(e) −55.84 kJ mol^{-1}

E3.32 +11.3 kJ mol^{-1} .

E3.33 −56.98 kJ mol^{-1}

E3.34 40.88 kJ mol^{-1}

E3.35 (a) Decrease
(b) Decrease
(c) Increase

E3.36 (a) Increase
(b) Increase

CHAPTER 4

Thermodynamics: the Second Law

E4.1 0.410 J K^{-1}

E4.2 (a) +0.12 kJ K^{-1}.
(b) −0.12 kJ K^{-1}

E4.3 (a) −45.1 kJ
(b) −165 J K^{-1}

E4.5 +14 J K^{-1} mol^{-1}

E4.6 2.91 dm^3

E4.7 33 J K^{-1}

E4.8 23.6 J K^{-1}

E4.9 −93.0 J K^{-1}

E4.10 8.64% high

E4.11 −7.9 J K^{-1} mol^{-1}

E4.12 0.6300 T_i

E4.14 4.0×10^{-4} J K^{-1} mol^{-1}

E4.15 5.11 J K^{-1}

E4.16 0.95 J K^{-1} mol^{-1}

E4.17 (a) +87.8 J K^{-1} mol^{-1}
(b) −87.8 J K^{-1} mol^{-1}.

E4.18 79 J K^{-1} mol^{-1}

E4.19 (a) +85 J K^{-1} mol^{-1}.
(b) +34 kJ K^{-1} mol^{-1}

E4.20 $kN\ln\left(\frac{V_f}{V_i}\right)$

E4.21 11.5 J K^{-1} mol^{-1}

E4.22 (a) positive
(b) negative
(c) positive

E4.23 (a) −386.1 $JK^{-1}mol^{-1}$
(b) +92.6$JK^{-1}mol^{-1}$
(c) −153.1 J K^{-1} mol^{-1}
(d) −21.0 J K^{-1} mol^{-1}
(e) +512.0 J K^{-1} mol^{-1}

E4.24 5.03 kJ K^{-1}

E4.25 (a) −198.72 J K^{-1}
(b) 309 J K^{-1}

E4.26 (a) −0.75 J K^{-1}
(b) +0.15 J K^{-1}

E4.27 −32.99 kJ

E4.28 (a) −93 kJ mol^{-1}
(b) Yes, ΔG is negative.
(c) +0.30 kJ K^{-1} mol^{-1}

E4.29 0.41 g

E4.30 17 J

E4.31 (a) Yes
(b) 0.46 mol ATP

E4.32 8.1×10^{23} molecules of ATP

E4.33 (a) Density of cell = 13 W m^{-3}
(b) Density of battery = 150 kW m^{-3}
(c) The battery.

CHAPTER 5

Physical Equilibria: Pure Substances

E5.1 Rhombic sulfur

E5.2 No

E5.3 (a) +2.03 kJ mol^{-1}
(b) +1.50 J mol^{-1}

E5.4 +14 kJ mol^{-1}

E5.5 (a) +2.7 kJ mol^{-1}
(b) −2.0 kJ mol^{-1}

E5.6 +4.2 kJ mol^{-1}

E5.7 710 K

E5.8 −3.5 kJ mol^{-1}

E5.10 (a) 1.1 kg
(b) 15 kg
(c) 1.1 g

E5.11 (a) −134.6 bar K^{-1}
(b) 135.6 bar .

E5.12 (a) 31.69 kJ mol^{-1}
(b) $37\overline{3}$ K

E5.13 8.330

E5.14 0.758 Pa

E5.15 36.7 kJ mol^{-1}

E5.16 353 K

E5.17 (a) 3
(b) 1

E5.18 (a) 2
(b) 2

E5.19 (a) Yes
(b) 3.0 Torr or more

CHAPTER 6

The Properties of Mixtures

E6.1 886.8 cm^3

E6.2 96.9 cm^3

E6.3 1.8 kJ mol^{-1}

E6.4 32.631 J mol^{-1}

E6.5 (a) −1.31 kJ mol^{-1}
(b) +4.38 J K^{-1} mol^{-1}
(c) Yes.

E6.7 4.99 kPa

E6.8 2.30 kPa

E6.9 6.4×10^3 kPa

E6.10 4.8×10^{-3}

E6.11 128 kPa

E6.12 (a) 1.3 mmol dm^{-3}
(b) 17.0 mmol dm^{-3}

E6.14 34.5 mmol dm^{-3}

E6.18 –5.6 kJ mol^{-1}

E6.19 59.1 g mol^{-1}

E6.20 –0.068°C

E6.21 –0.40°C

E6.22 207 g mol^{-1}

E6.23 $K = \dfrac{1-\dfrac{r(p^* - p)}{cp}}{c\left(1-\dfrac{2r(p^* - p}{cp}\right)^2}$.

E6.24 –0.11°C

E6.25 86.4 kg mol^{-1}

E6.26 13.9$\overline{3}$ kg mol^{-1}

E6.32 (a) 5% tin by mass
(b) No Ag_3Sn in the sold
(c) 20% Ag_3Sn by mass

E6.38 0.25

CHAPTER 7
Chemical Equilibrium: The Principles

E7.1 (a) $Q = \dfrac{p_{CO_2}^6}{[CH_3COCOOH]^2\, p_{O_2}^5}$

(b) $Q = \dfrac{[FeSO_4]}{[PbSO_4]}$

(c) $K = \dfrac{[HCl]^2}{p_{H_2}}$

(d) $Q = \dfrac{[CuCl_2]}{[CuCl]^2}$

E7.2 (a) $K = \dfrac{p_{COCl}\, p_{Cl}}{p_{CO}\, p_{Cl_2}}$

(b) $K = \dfrac{p_{SO_3}^2}{p_{SO_2}^2\, p_{O_2}}$

(c) $K = \dfrac{p_{HBr}^2}{p_{H_2}\, p_{Br_2}}$

(d) $K = \dfrac{p_{O_2}^3}{p_{O_3}^2}$

E7.3 –14.4 kJ mol^{-1}

E7.4 2.31

E7.5 (a) 5.2×10^{11}
(b) 8.5×10^{2}

E7.6 –2.42 kJ mol^{-1}

E7.7 3.01

E7.8 1.38×10^{46}.

E7.9 –245 kJ mol^{-1}

E7.10 $K = 1$

E7.11 $K(\text{G1P}) = 3.5\times10^{3}$
$K(\text{G6P}) = 2.3\times10^{2}$
$K(\text{G3P}) = 36$

E7.12 (a) –48.3 kJ mol^{-1}
(b) –66.1 kJ mol^{-1}

E7.13 –30 kJ mol^{-1}

E7.14 –0.7 kJ mol^{-1}

E7.15 6.8 kJ mol^{-1}

E7.16 (a) 1110 K (837°C)
(b) 397 K (124°C)

E7.17 1.50×10^{3} K

E7.18 0.0031

E7.20 (a) –, exergonic
(b) +, endergonic
(c) +, endergonic
(d) –, exergonic

E7.21 (a) -91.14 kJ mol^{-1}
(b) $+594.6$ kJ mol^{-1}
(c) -66.8 kJ mol^{-1}
(d) $+99.8$ kJ mol^{-1}
(e) -415.80 kJ mol^{-1}

E7.22 (a) -522.1 kJ mol^{-1}, $K > 1$
(b) $+25.78$ kJ mol^{-1}, $K < 1$
(c) -178.6 kJ mol^{-1}, $K > 1$
(d) -212.55 kJ mol^{-1}, $K > 1$
(e) -5798 kJ mol^{-1}, $K > 1$

E7.23 (a) 1.1×10^{5} kJ
(b) 1.0×10^{5} kJ

E7.24 (a) 2.8×10^{4} kJ
(b) 3.1×10^{4} kJ

E7.26 -49.8 kJ mol^{-1}

E7.27 817.90 kJ mol^{-1}

E7.28 -25.1 kJ mol^{-1}

E7.29 26 kJ mol^{-1}

E7.32 -16.8 J K^{-1} mol^{-1}

E7.33 $+12.3$ kJ mol^{-1}

E7.36 2.7×10^{-4} bar

E7.37 (a) 0.016 mol dm^{-3}
(b) 45%

E7.39 $\alpha \propto p^{-1/2}$

E7.40 -41.0 kJ mol^{-1}

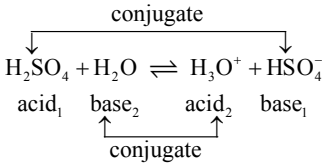
E7.41 (a) $+52.9$ kJ mol^{-1}
(b) -52.9 kJ mol^{-1}

E7.42 (a)
(1) 9.24
(2) 31.08
(b)
(1) -12.9 kJ mol^{-1}
(2) -20.9 kJ mol^{-1}
(c) $+161$ kJ mol^{-1}
(d) $+248$ J K^{-1} mol^{-1}

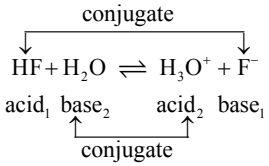
CHAPTER 8

Chemical Equilibrium: Equilibria In Solution

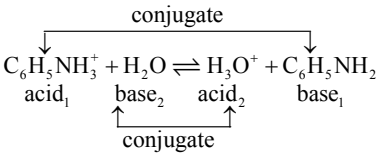
E8.1 (a)



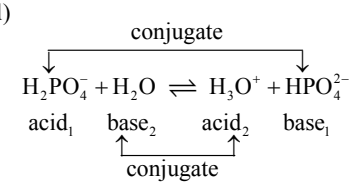
(b)



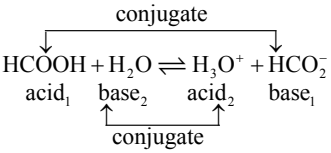
(c)



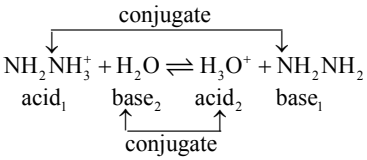
(d)



(e)



(f)



E8.6 $\dfrac{\Delta_r H^{\ominus}}{\ln 10 \times R}$

E8.7 57.1 kJ mol^{-1}

E8.9 8.02

E8.13 9.2

E8.14 4.77

E8.15 none of the Br^- is protonated

E8.16 (a) 8.32×10^{-4}
(b) 2.78

E8.18 (a) 1.6%

(b) 0.33%

(c) 2.4%

E8.22 2.71

E8.23 (a) 6.54

(b) 2.12

(c) 1.49

E8.25 (a) 1.59×10^{-5}

(b) 0

(c) 5.01

E8.27 (a) 2.9

(b) 4.6

(c) 12.5 cm^3 of 0.10 M NaOH(aq)

(d) 4.74

(e) 25.0 cm^3

(f) 8.72

E8.28 (a) 4.75

(b) 5.04

(c) 4.15

E8.29 (a) 2–4

(b) 3–5

(c) 11.5–13. 5

(d) 6–8

(e) 5–7

E8.31 (a) 5.1

(b) pOH = 5.0
pH = 9.0

(c) 2.7

E8.32 8.00

E8.34 (a) H_3PO_4 and NaH_2PO_4

(b) NaH_2PO_4 and Na_2HPO_4, or $NaHSO_3$ and Na_2SO_3

E8.35 (a) $K_s = [Ag^+]\,[I^-]$

(b) $K_s = [Hg_2^{+2}]\,[S^{2-}]$

(c) $K_s = [Fe^{3+}]\,[OH^-]^3$

(d) $K_s = [Ag^+]^2\,[CrO_4^{2-}]$

E8.36 (a) 1.0×10^{-5} mol dm^{-3}

(b) 1.2×10^{-4} mol dm^{-3}

(c) 9.3×10^{-11} mol dm^{-3}

(d) 6.9×10^{-7} mol dm^{-3}

E8.37 (a) 5.5×10^{-10} mol dm^{-3}

(b) 3.2×10^{-3} mol dm^{-3}

(c) 1.6×10^{-7} mol dm^{-3}

(d) 2.5×10^{-7} mol dm^{-3}

E8.38 161 kJ mol^{-1}

E8.39 1.25×10^{-5} mol dm^{-3}

E8.40 (a) $\dfrac{S'}{S} = e^{\frac{\Delta_s H^{\ominus}}{2R}\left(\frac{1}{T}-\frac{1}{T'}\right)}$

(b) Increases.

CHAPTER 9

Chemical Equilibrium: Electrochemistry

E9.1 1.35

E9.2 (a) 2.73 g

(b) 2.92 g

E9.3 $\gamma_{\pm} = \left(\gamma_+ \gamma_-^2\right)^{1/3}$

E9.5 $B = 2.01$

E9.6 13.83 mS m^2 mol^{-1}

E9.7 7.63 mS m^2 mol^{-1}

E9.10 1.36×10^{-5} M

E9.11 3.70

E9.12 4.9

E9.14 –440 kJ mol^{-1}

E9.15 28 mV

E9.16 –1.18V

E9.17

(a) R: $Ag^+(aq, b_R) + e^- \rightarrow Ag(s)$
L: $Ag^+(aq, b_L) + e^- \rightarrow Ag(s)$
R–L: $Ag^+(aq, b_R) \rightarrow Ag^+(aq, b_L)$

(b) R: $2\,H^+(aq) + 2\,e^- \rightarrow H_2(g, p_R)$
L: $2\,H^+(aq) + 2\,e^- \rightarrow H_2(g, p_L)$
R–L: $H_2(g, p_L) \rightarrow H_2(g, p_R)$

(c) R: $MnO_2(s) + 4\,H^+(aq) + 2\,e^- \rightarrow Mn^{2+}(aq) + 2\,H_2O(l)$
L: $[Fe(CN)_6]^{3-}(aq) + e^- \rightarrow [Fe(CN)_6]^{4-}(aq)$
R–L: $MnO_2(s) + 4\,H^+(aq) + 2\,[Fe(CN)_6]^{4-}(aq) \rightarrow Mn^{2+}(aq) + 2\,[Fe(CN)_6]^{3-}(aq) + 2\,H_2O(l)$

(d) R: $Br_2(l) + 2\ e^- \rightarrow 2\ Br^-(aq)$
L: $Cl_2(g) + 2\ e^- \rightarrow 2\ Cl^-(aq)$
R–L: $Br_2(l) + 2\ Cl^-(aq) \rightarrow Cl_2(g) + 2\ Br^-(aq)$

(e) R: $Sn^{4+}(aq) + 2\ e^- \rightarrow Sn^{2+}(aq)$
L: $2\ Fe^{3+}(aq) + 2\ e^- \rightarrow 2\ Fe^{2+}(aq)$
R–L: $Sn^{4+}(aq) + 2\ Fe^{2+}(aq) \rightarrow Sn^{2+}(aq) + 2\ Fe^{3+}(aq)$

(f) R: $MnO_2(s) + 4\ H^+(aq) + 2e^- \rightarrow Mn^{2+}(aq) + 2\ H_2O(l)$
L: $Fe^{2+}(aq) + 2\ e^- \rightarrow Fe(s)$
R–L: $Fe(s) + MnO_2(s) + 4\ H^+(aq) \rightarrow Fe^{2+}(aq) + Mn^{2+}(aq) + 2\ H_2O(l)$

E9.18 (a) $E = E^\ominus - \dfrac{RT}{F}\ln\dfrac{b_L}{b_R}$

(b) $E = E^\ominus - \dfrac{RT}{2F}\ln\dfrac{p_R}{p_L}$

(c) $E = E^\ominus - \dfrac{RT}{2F}\ln\left(\dfrac{[Mn^{2+}][Fe(CN)_6^{3-}]^2}{[H^+]^4[Fe(CN)_6^{4-}]^2}\right)$

(d) $E = E^\ominus - \dfrac{RT}{2F}\ln\left(\dfrac{p_{Cl_2}[Br^-]^2}{[Cl^-]^2}\right)$

(e) $E = E^\ominus - \dfrac{RT}{2F}\ln\left(\dfrac{[Sn^{2+}][Fe^{3+}]^2}{[Sn^{4+}][Fe^{2+}]^2}\right)$

(f) $E = E^\ominus - \dfrac{RT}{2F}\ln\left(\dfrac{[Fe^{2+}][Mn^{2+}]}{[H^+]^4}\right)$

E9.19 (a) $\nu = 2$
(b) $\nu = 2$
(c) $\nu = 4$
(d) $\nu = 2$
(e) $\nu = 2$
(f) $\nu = 1$

E9.20 (a) 0
(b) 0
(c) +0.87 V
(d) −0.27 V
(e) −0.62 V
(f) +1.67 V

E9.21 (a) 0.08 V
(b) +0.27
(c) +1.23 V
(d) +0.695 V
(e) +0.54 V
(f) +0.36 V

E9.22 (a) +1.23 V
(b) +1.11 V

E9.23 (a) partial oxidation of methane occurs at the cathode.
(b) 0.09 V

E9.24 (a) +0.94 V
(b) $E = 1.51 - 0.0947\ \text{pH}$

E9.25 (a) E decreases,

\ $E = E^\ominus - \dfrac{RT}{F}\ln\left(\dfrac{[Ag^+]_L}{[Ag^+]_R}\right)$

(b) E increases,

$E = E^\ominus - \dfrac{RT}{2F}\ln\left(\dfrac{p_R}{p_L}\right)$

(c) E increases,

$E = E^\ominus - \dfrac{RT}{2F}\ln\left(\dfrac{[Mn^{2+}][Fe(CN)_6^{3-}]^2}{[H^+]^4[Fe(CN)_6^{4-}]^2}\right)$

(d) E increases,

$E = E^\ominus - \dfrac{RT}{2F}\ln\left(\dfrac{[Br^-]^2\,p_{Cl_2}}{[Cl^-]^2}\right)$

(e) E decreases,

$E = E^\ominus - \dfrac{RT}{2F}\ln\left(\dfrac{[Sn^{2+}][Fe^{3+}]^2}{[Sn^{4+}][Fe^{2+}]^2}\right)$

(f) E increases,

$E = E^\ominus - \dfrac{RT}{2F}\ln\left(\dfrac{[Fe^{2+}][Mn^{2+}]}{[H^+]^4}\right)$

E9.26 (a) decreases E
(b) decreases E
(c) increases E
(d) increases E
(e)
(i) decreases E
(ii) decreases E
(f) no effect

E9.27 (a) −1.20 V
(b) −1.19 V

E9.28 (a) −1.55 V
(b) chlorinespontaneously oxidizes water to oxygen under both acidic and basic conditions

E9.29 (a) $-394\ \text{kJ mol}^{-1}$
(b) $-788\ \text{kJ mol}^{-1}$.
(c) $+75\ \text{kJ mol}^{-1}$
(d) $-291\ \text{kJ mol}^{-1}$
(e) $-291\ \text{kJ mol}^{-1}$.
(f) $+498\ \text{kJ mol}^{-1}$

E9.30 (a) $-440\ \text{kJ mol}^{-1}$
(b) $+29.7\ \text{kJ mol}^{-1}$
(c) $-313\ \text{kJ mol}^{-1}$

E9.31 (a) +0.324 V
(b) +0.45 V

E9.32 0.37 V

E9.34 (a) $-667\ \text{kJ mol}^{-1}$
(b) $-604\ \text{kJ mol}^{-1}$

E9.35 +0.22 V

E9.36 (a) −0.6111 V
(b) −0.22 V.
(c) $E_{\text{cell}} = E^{\ominus}_{\text{cell}} - \dfrac{RT}{F}\ln\left(\dfrac{a_{\text{HCO}_3^-}a_{\text{OH}^-}}{a_{\text{CO}_3^{2-}}}\right)$
(d) +0.41
(e) 10.33

E9.37 (a) 6.5×10^{9}
(b) 1.2×10^{7}
(c) $K = \text{e}^{101} = 7.3\times10^{43}$
(d) 1.0×10^{25}
(e) 8.3×10^{-7}
(f) 1.6×10^{3}

E9.38 $E = E^{\ominus} - \dfrac{RT}{6F}\ln\left(\dfrac{a^2_{\text{Cr}^{3+}}}{a_{\text{Cr}_2\text{O}_7^{2-}}a^{14}_{\text{H}^+}}\right)$.

E9.39 (1) 1.80×10^{-10}
(2) 9.04×10^{-7}

E9.40 0.78

E9.41 −0.73 V

E9.42 (a) $9.19\times10^{-9}\ \text{mol dm}^{-3}$
(b) 8.45×10^{-17}

CHAPTER 10

Chemical Kinetics: The Rates of Reactions

E10.1 $2.1\ \text{mmol dm}^{-3}$

E10.3 $0.80\ \text{mol dm}^{-3}\ \text{s}^{-1}$.

E10.4 $\text{mol}^{-2}\ \text{dm}^{6}\ \text{s}^{-1}$

E10.5 $\text{mol}^{-1}\ \text{dm}^{3}\ \text{s}^{-1}$

E10.6 $\text{kPa}^{-1/2}\ \text{s}^{-1}$

E10.7 $3.7\times10^{7}\ \text{dm}^3\ \text{mol}^{-1}\ \text{s}^{-1}$

E10.12 $1.12\times10^{-4}\,\text{s}^{-1}$

E10.13 $7.7\times10^{-5}\ \text{s}^{-1}$

E10.14 $1.09\times10^{-3}\ \text{dm}^3\ \text{mol}^{-1}\ \text{s}^{-1}$

E10.15 $1.12\times10^{-4}\ \text{s}^{-1}$

E10.16 $3.19\times10^{-6}\ \text{Pa}^{-1}\ \text{s}^{-1}$

E10.17 (a) $0.014\ \text{kPa s}^{-1}$
(b) $1.5\times10^{3}\ \text{s}$

E10.18 (a) $v = k_r\,[\text{ICl}]\,[\text{H}_2]$
(b) $0.16\ \text{dm}^3\ \text{mol}^{-1}\ \text{s}^{-1}$
(c) $2.0\times10^{-6}\ \text{moldm}^{-3}\ \text{s}^{-1}$

E10.23 $[\text{B}]_0 + \tfrac{1}{3}[\text{A}]_0\left\{k_r t[\text{A}]_0 / \left(1 + k_r t[\text{A}]_0\right)\right\}$

E10.26 $1.33\times10^{3}\ \text{s}$

E10.27 $3067\ \text{a} \pm 100\ \text{a}.$

E10.28 (a) $0.63\ \mu\text{g}$
(b) $0.16\ \mu\text{g}$

E10.29 $633\ \text{s}$

E10.30 (a) $0.138\ \text{mol dm}^{-3}$
(b) $0.095\ \text{mol dm}^{-3}$

E10.31 $6.8\ \text{s}$

E10.32 (a) $1.86\times10^{23}\ \text{a}.$
(b) $27.1\ \text{s}.$

E10.33 (a) $E_a = 104\ \text{kJ mol}^{-1}$
(b) $A = 1.12\times10^{15}\ \text{mol dm}^{-3}\ \text{s}^{-1}$

E10.34 $298.86\ \text{K}$

E10.35 $E_a = 52\ \text{kJ mol}^{-1}$

E10.36 $35.9\ \text{kJ mol}^{-1}$

E10.38 $121\ \text{kJ mol}^{-1}$

E10.39 $-21.6\ \text{kJ mol}^{-1}$

E10.40 $47.8\ \text{kJ mol}^{-1}$

E10.41 (a) $1.62\times10^{-20}.$
(b) $5.52\times10^{-13}.$

E10.42 $4\times10^{11}\ \text{dm}^3\ \text{mol}^{-1}\ \text{s}^{-1}$

E10.43 $2.1\ \text{nm}^2$

E10.44 $12\overline{6}\ \text{kJ mol}^{-1}$

E10.45 $\Delta^{\ddagger}S \approx 0$

CHAPTER 11

Accounting for the Rate Laws

E11.1 $7.5\times10^{5}\ \text{s}^{-1}$

E11.2 (a) $1.28\times10^{4}\ \text{mol}^{-1}\ \text{dm}^3\ \text{s}^{-1}$
(b) $4.00\times10^{10}\ \text{mol}^{-1}\ \text{dm}^3\ \text{s}^{-1}$

E11.3 $39.1\ \text{d}$

E11.4 The reaction is first – order in H_20_2 and in Br^-, and second – order overall

E11.5 $k_{r,\text{eff}}[\text{A}_2]^{1/2}[\text{B}]$ where $k_{r,\text{eff}} = k_b(K$

E11.7 $v = \dfrac{k_1 k_2[\text{O}_3]^2}{k_1'[\text{O}_2] + k_2[\text{O}_3]}$

E11.8 $k_{r,\text{eff}}[\text{A}]$ where $k_{r,\text{eff}} = \dfrac{k_a k_b[\text{M}]}{k_a'[\text{M}] + k_b}$

E11.9

$k_{r,\text{eff}}[\text{A}]$ where $k_{r,\text{eff}} = \dfrac{(k_A[\text{A}] + k_M[\text{M}])k_b}{k_A'[\text{A}] + k_M'[\text{M}] + k_b}$

E11.11 1.89×10^{-6} Pa^{-1} s^{-1}

E11.12 (a) 6.61×10^{6} m^3 mol^{-1} s^{-1}

(b) 3.0×10^{7} m^3 mol^{-1} s^{-1}

E11.13 (a) -5.2×10^{-8} mol m^{-2} s^{-1}

(b) 1.6×10^{-11} mol

E11.14 (a) 27 h

(b) 2.7×10^{3} h

(c) 3.0×10^{3} a

E11.15 (a) 6.3×10^{-9} m^2 s^{-1}

(b) 1.6×10^{-9} m^2 s^{-1}

E11.16 8.55×10^{4} a

E11.17 1×10^{6} steps

E11.18 16.8 kJ mol^{-1}

E11.19 5.6×10^{22}

E11.20

(a) Concentration: $[\text{A}^-] = \dfrac{k_{r1}[\text{HA}][\text{B}]}{k_{r2}[\text{BH}^+] + k_{r3}[\text{HA}]}$

(b)Rate equation: $\dfrac{k_{r1}k_{r3}[\text{HA}]^2[\text{B}]}{k_{r2}[\text{BH}^+] + k_{r3}[\text{HA}]}$

E11.21 $\dfrac{k_a k_b}{k_a'}[\text{HA}][\text{H}^+][\text{B}]$

E11.23 1.62 mmol dm^{-3} s^{-1}

E11.24 7.9×10^{6} dm^3 mol^{-1} s^{-1}

E11.27 $\text{AH} \xrightarrow{k_a} \text{A}\cdot + \text{H}\cdot$ initiation

$\text{A}\cdot \xrightarrow{k_b} \text{B}\cdot + \text{C}$ propagation

$\text{AH} + \text{B}\cdot \xrightarrow{k_c} \text{A}\cdot + \text{D}$ propagation

$\text{A}\cdot + \text{B}\cdot \xrightarrow{k_d} \text{P}$ termination

CHAPTER 12

Quantum Theory

E12.1 3.05×10^{-19} J

E12.2 8.226×10^{4} cm^{-1}

E12.3 8.4×10^{11} s^{-1}

E12.5 (a) 1.91×10^{18} s^{-1}

(b) 1.91×10^{18} s^{-1}

E12.6 2.03×10^{3} s

E12.7 6.90×10^{29} s^{-1}

E12.10 1.32×10^{6} m s^{-1}

E12.11 (a) 6.6×10^{-31} m

(b) 6.6×10^{-39} m

(c) 99.7 pm

E12.12 (a) 1.23 nm

(b) 39 pm

(c) 3.88 pm

E12.13 3.5×10^{-36} m

E12.14 (a) 1.10×10^{-27} kg m s^{-1}

(b) 9.5×10^{-24} kg m s^{-1}

(c) 3.31×10^{-36} kg m s^{-1}

E12.16 $2.2\times10^{-24}\,\text{m s}^{-1}$

E12.17 (a) 6.14×10^{-4} N
(b) 614 pPa
(c) 0.452 h

E12.18 50.6 nm

E12.19 1.74×10^{-15} J

E12.20 $-\frac{\hbar^2}{2m}\frac{\mathrm{d}^2\psi}{\mathrm{d}x^2}+ax^4\psi=E\psi$

E12.22 (a) $1.\overline{77}\times10^{-4}$
(b) $5.\overline{92}\times10^{-5}$

E12.23 0.90 nm

E12.24 $2.1\times10^{-29}\,\text{m s}^{-1}$

E12.25 1.0×10^{-26} m

E12.26 $5.8\times10^{5}\,\text{m s}^{-1}$

E12.28 $9.84\times10^{-23}\,\text{J}$

E12.29 $L/4$ and $3L/4$

E12.30 (a) $2.1\overline{7}\times10^{-20}\,\text{J}$
(b) 9.2 μm

E12.31 $\psi=\left(\frac{1}{L}\right)^{1/2}$.

E12.32 1.24 μm

E12.35 (a) 4.34×10^{-47} kg m^2
(b) 1.55 mm

E12.36 $8.79\times10^{11}\,\text{s}^{-1}$

E12.37 2.91×10^{-22} J

E12.38 1.05×10^{-22} J

E12.39 0.04 N m^{-1}

E12.40 (a) $6.89\times10^{13}\,\text{s}^{-1}$
(b) 4.35 μm

CHAPTER 13

Atomic Structure

E13.1 410.296 nm

E13.2 6

E13.3 (a)
$27414\ \text{cm}^{-1}-20572\ \text{cm}^{-1}=684\overline{2}\ \text{cm}^{-1}$
(b) 1.36×10^{-19} J

E13.4 27 cm^{-1}

E13.5 $n_1 = 2$ and $n_2 = 4$

E13.8 122.31 eV

E13.9 16 orbitals

E13.10 All lines fit
(a) $n_2 \to 6$
(b) 12372 nm, 7503 nm, 5908 nm, 5129 nm, ¼ 3908 nm $(\text{at } n_2 = 15)$, converging to 3282 nm as $n_2 \to \infty$

E13.11 3093.00 nm

E13.12 (a) 397.13 nm
(b) 274 19 cm^{-1}or 3.40 eV

E13.13 (a) $R_{\text{Li}^{2+}} = 109\,740\ \text{cm}^{-1}$

(b) 137 175 cm^{-1}, 185 186 cm^{-1},…

(c) 987660 cm^{-1} or 122.45 eV

E13.14 $r = 0.602\ a_0$

E13.16 ½

E13.17 (a) 1.3×10^{-5}

(b) 5.1×10^{-5}

E13.19 Sin θ goes to zero at $\theta = 0^\circ$ and 180°
cos θ goes to zero at 90° and 270°

E13.20 (a) ang. mom. = 0

(b) ang. mom. = 0

(c) ang. mom. $= \sqrt{6}\ \hbar$

(d) ang. mom. $= \sqrt{2}\ \hbar$

(e) ang. mom. $= \sqrt{2}\ \hbar$

E13.21 (a) $g = 1$

(b) $g = 9$

(c) $g = 49$

E13.22 $2(2l + 1)$

E13.23 $I_1^- = E_{ea}$

E13.24 14.0 eV

E13.26 $^3F_2$

E13.27 2, 1, and 0

E13.28 (a) 1 level

(b) 3 levels

(c) 1 level

(d) 3 levels

E13.29 Ti^{2+}: $[Ar]3d^2$

(a) ^3F

(b) 5

E13.30

(a) Forbidden

(b) Allowed

(c) Allowed

(d) Forbidden

(e) Allowed

(f) Forbidden

E13.32

(a) Allowed

(b) Forbidden

(c) Allowed

CHAPTER 14

The Chemical Bond

E14.3

$$\psi_1(\sigma\text{-bond}) = \psi_{2p_zA}(1)\ \psi_{2p_zB}(2) + \psi_{2p_zA}(2)\ \psi_{2p_zB}(1)$$

$$\psi_2(\pi\text{-bond}) = \psi_{2p_xA}(1)\ \psi_{2p_xB}(2) + \psi_{2p_xA}(2)\ \psi_{2p_xB}(1)$$

$$\psi_3(\pi\text{-bond}) = \psi_{2p_yA}(1)\ \psi_{2p_yB}(2) + \psi_{2p_yA}(2)\ \psi_{2p_yB}(1)$$

E14.4 $1.87\times 10^6\ J\ mol^{-1}$

E14.5
$$\psi_{\sigma1} = h_1(1)\ \psi_{1sH1}(2) + h_1(2)\ \psi_{1sH1}(1)$$
$$\psi_{\sigma2} = h_2(1)\ \psi_{1sH2}(2) + h_2(2)\ \psi_{1sH2}(1)$$
$$\psi_{\sigma3} = h_3(1)\ \psi_{1sH3}(2) + h_3(2)\ \psi_{1sH3}(1)$$
$$\psi_{\sigma4} = h_4(1)\ \psi_{1sH4}(2) + h_4(2)\ \psi_{1sH4}(1)$$

E14.8 210 times.

E14.10 45°

E14.12

(a) Li_2	$1\sigma_g^{\,2}$	$b = 1$
(b) Be_2	$1\sigma_g^{\,2}1\sigma_u^{\,2}$	$b = 0$
(c) C_2	$1\sigma_g^{\,2}1\sigma_u^{\,2}1\pi_u^{\,4}$	$b = 2$

E14.13

(a) H_2^- $1\sigma_g^{\,2}1\sigma_u^{\,1}$ $b = \frac{1}{2}$

(b) N_2 $1\sigma_g^{\,2}1\sigma_u^{\,2}1\pi_u^{\,4}2\sigma_g^{\,2}$ $b = 3$

(c) O_2 $1\sigma_g^{\,2}1\sigma_u^{\,2}2\sigma_g^{\,2}1\pi_u^{\,4}1\pi_g^{\,2}$ $b = 2$

E14.14

(a) CO $1\sigma^2 2\sigma^{*2}1\pi^4 3\sigma^2$ $b = 3$

(b) NO $1\sigma^2 2\sigma^{*2}1\pi^4 3\sigma^2 2\pi^{*1}$ $b = 5/2$

(c) CN^- $1\sigma^2 2\sigma^{*2}1\pi^4 3\sigma^2$ $b = 3$

E14.15 C_2

E14.16 C_2 and CN are stabilized by anion formation. NO, O_2, and F_2 are stabilized by cation formation.

E14.17 C_2

E14.14 XeF^+ will have a shorter bond length than XeF

E14.19 (a) g
(b) inapplicable
(c) g
(d) u

E14.21 (a) g
u
g
u

(b) If v is even, ψ_v is g.
If v is odd, ψ_v is u.

E14.23 N_2

E14.24 $F_2^+ < F_2 < F_2^-$

E14.25 $F_2^+ > F_2 > F_2^-$

E14.26 $O_2^+, O_2, O_2^-, O_2^{2-}$

E14.27 $O_2^{\,+} > O_2 > O_2^{\,-} > O_2^{\,2-}$

E14.30 (a) nonpolar
(b) polarized

E14.34 32 molecular oribtals

E14.35

(a) $\beta / hc \sim -40000\ \text{cm}^{-1}\ (-5.0\ \text{eV})$

(b) $E_{\text{deloc}} / hc = 60720\ \text{cm}^{-1}\ (7.35\ \text{eV})$

CHAPTER 15

Molecular Interactions

E15.1 1.9 D

6.3×10^{-30} C m

E15.2 nonpolar

E15.3 (a) 0.7 D
(b) 0.4 D
(c) 0

E15.4 1.26 D

E15.5 (a) 0.8 D
(b) 0.4 D
(c) 0

E15.6 (a) 1.414 D
(b) 2.45 D
(c) 1.06 D
(d) 1.70 D

E15.8 3.50 D

E15.10 (a) 476 kJ mol^{-1}
(b) 87.4 kJ mol^{-1}

E15.12 (a) 3.7 kJ mol^{-1}

(b) $-0.365\ \text{J mol}^{-1}$
(c) Yes.

E15.14 196 pm

E15.15 -2.32×10^{-24} J

E15.16 $-1.8\times10^{-27}\ \text{J} = -1.1\times10^{-3}\ \text{J mol}^{-1}$

E15.17 $-4.2\times10^{-3}\ \text{J mol}^{-1}$

E15.18 $-42\ \text{kJ mol}^{-1}$

E15.20 $R = 461.2$ pm

CHAPTER 16
Materials: Macromolecules and Aggregates

E16.1 (1) $95\ \text{kg mol}^{-1}$
(2) $97\ \text{kg mol}^{-1}$

E16.2 (a) $18\ \text{kg mol}^{-1}$
(b) $20\ \text{kg mol}^{-1}$

E16.3 1.27

E16.4 244

E16.5 $3.1\times10^{3}\ \text{kg mol}^{-1}$

E16.6 (a) 880 nm
(b) 31.1 nm

E16.8 1.3×10^{4}

E16.11 -5.0×10^{-3}

E16.13
$$[\text{S}] = \frac{-1+\sqrt{1+8K[\text{S}]_{\text{total}}}}{4K} \quad \text{and}$$
$$[\text{S}_2] = \frac{1}{2}\left\{[\text{S}]_{\text{total}} - \frac{-1+\sqrt{1+8K[\text{S}]_{\text{total}}}}{4K}\right\}$$

E16.15 (a) 1.4 kPa
(b) 0.14 kPa

E16.16 5.8 cm

E16.17 $45\ \text{mN m}^{-1}$

E16.18 $97\ \text{mmol m}^{-2}$

CHAPTER 17
Metallic, Ionic, and Covalent Solids

E17.1 (a) n-type
(b) p-type

E17.2 metallic condusctor

E17.6 $3500.\ \text{kJ mol}^{-1}$

E17.7 $2149.8\ \text{kJ mol}^{-1}$

E17.8 $\dfrac{Q\ Nze\ \pi}{48\ \varepsilon_0 d}$

E17.9 1.06

E17.10 6.0 K

E17.16 $d_{111} = 330$ pm
$d_{211} = 234$ pm
$d_{100} = 572$ pm

E17.17 $d_{123} = 135$ pm
$d_{236} = 70.1$ pm

E17.18 66.1 pm

E17.19 bbc unit cell

E17.20 (b) $8.97\ \text{g cm}^{-3}$

E17.22 0.9069

E17.24 0.740 g cm^{-3}

E17.25 (a) 8
(b) 6
(c) 520 nm
(d) 600 nm

E17.26 (a) 12
(b) 6
(c) 424 nm
(d) 600 nm

E17.27 (a) less dense
(b) 92%

E17.28 $V = 3.96\times10^{-28}\,\text{m}^3$
$d = 2.41\times10^{6}\ \text{g m}^{-3}$

E17.29 (a) $N = 4$
(b) 4.01 g cm^{-3}

E17.30 (a) 220 pm
(b) 110 pm

CHAPTER 18

Solid Surfaces

E18.2 0.088 bar

E18.3 $2.1\times10^{5}\ \text{s}^{-1}$

E18.4 1.15

E18.5 (a) $1.\overline{1}\times10^{10}\ \text{s}^{-1}$
(b) 0.24

E18.6 49 m^2

E18.7 (a) 0.060 kPa
(b) 4.9 kPa

E18.8 $\dfrac{s_0 e^{E_d/RT}}{(2\pi mkT)^{1/2}A}$

E18.10 $-2\overline{5}$ kJ mol^{-1}

E18.12 $p = \dfrac{1}{K}\left(\dfrac{\theta}{1-\theta}\right)^2$

E18.13 $\theta = \dfrac{(Kp)^{1/3}}{1+(Kp)^{1/3}}$

E18.16 $4\overline{5}$ s

E18.17 (a) $61\overline{1}$ kJ mol^{-1}
(b) $9.3\times10^{12}\ \text{s}^{-1}$

E18.18 (a) 2.7×10^{91} a
(b) 0.17 ms

E18.19 0.45

E18.22 155 mV

E18.23 1.68 mA cm^{-2}

E18.24 (a) 0.31 mA cm^{-2}
(b) 5.41 mA cm^{-2}
(c) -1.43×10^{39} A cm^{-2}

E18.25 (a) $4.9\times10^{15}\ \text{s}^{-1}$
(b) $1.6\times10^{16}\ \text{s}^{-1}$
(c) $3.1\times10^{7}\ \text{s}^{-1}$

CHAPTER 19

Spectroscopy: Molecular rotations and vibrations

E19.1 (a) $6.78\times10^{14}\ \text{s}^{-1} = 6.78\times10^{14}$ Hz
(b) $2.26\times10^{4}\ \text{cm}^{-1}$

Deleted: E

E19.2 (a) 2.94×10^{-3} cm^{-1}
(b) 3.40 m

E19.3 4×10^{33}

E19.4 (a) 4.601×10^{-48} kg m^2
(b) 9.196×10^{-48} kg m^2
(c) 7.15×10^{-46} kg m^2
(d) $7.156.67\times10^{-46}$ kg m2

E19.5 (a) 1.824×10^{12} Hz
(b) 9.126×10^{11} Hz
(c) 1.17×10^{10} Hz
(d) 1.17×10^{10} Hz

E19.6 (a) $I = 4m_B R^2$
(b) 2.663×10^{9} Hz

E19.8 (a) 5.152×10^{9} Hz
(b) Could not be used.

E19.9 (a) Yes
(b) Yes
(c) Yes
(d) Yes
(e) No

E19.10 All will show

E19.11 289

E19.12 17

E19.13 (a) 636 GHz, 1272 GHz, 1908 GHz…
(b) 21.21 cm^{-1}
21.21 cm^{-1}, 42.42 cm^{-1}, 63.63 cm^{-1},…

E19.14 232.1 pm

E19.15 Lower

E19.16 20603 cm^{-1}

E19.17 116.2 pm

E19.18 (a) 162.2 pm
(b) 194 GHz

E19.19 (a) $\tilde{B} = 0.202852$ cm^{-1}
(b) $\tilde{D} = 6.2\times10^{-8}$ cm^{-1}

E19.20 (a) 116.28 pm
(b) 155.97 pm

E19.21 (a) 0.999 999 9029×660 nm
(b) 6.36×10^{7} m s^{-1}

E19.22 (a) 2.397×10^{7} m s^{-1}
(b) 8.4×10^{5} K

E19.23 (a) 53 ps
(b) 5.3 ps
(c) 1.6×10^{2} ps

E19.24 (a) $\tilde{\nu} = 53$ cm^{-1}.
(b) $\tilde{\nu} = 0.27$ cm^{-1}.

E19.25 (a) 4.49×10^{13} Hz
(b) 4.39×10^{13} Hz

E19.26 329 N m^{-1}

E19.29 2700.6 cm^{-1}

E19.30 (b) HCl, (c) CO_2, (d) H_2O,
(e) CH_3CH_3, (f) CH_4, and (g) CH_3Cl

E19.31 (a) 3
(b) 4
(c) 48
(d) 54

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CHAPTER 20

Electronic Transitions and Photochemistry

E20.1 (a) $1.48\times10^{4}\ \mathrm{dm^3\ mol^{-1}\ cm^{-1}}$
(b) 0.938%

E20.2 Absorbance: 0.658
Longer Cell: 1.3
Transmittance: 0.048

E20.3 $33\ \mu\mathrm{g\ dm^{-3}}$

E20.4 $c_A = 0.56\ \mathrm{mol\ dm^{-3}}$
$c_B = 0.16\ \mathrm{mol\ dm^{-3}}$

E20.5 Only two solutes in equilibrium with each other are present.

E20.6 Lengthen.
Blue.

E20.11 $16.0\bar{1}0^{-19}$ kJ

E20.12 (a) $2.1\bar{1}0^{-19}$ J
(b) $6.8\times10^{5}\ \mathrm{m\ s^{-1}}$

E20.13 10.20eV, 12.98 eV, and 15.99 eV

E20.14 2.0

E20.15 2.80

E20.16 Molecules destroyed: $1.47\times10^{19}\ \mathrm{s^{-1}}$
Chemical destroyed: $2.4\times10^{-5}\ \mathrm{mol\ s^{-1}}$

E20.17 Triplet state

E20.19 3.3×10^{18}

E20.21 $1.2\bar{7}\times10^{10}\ \mathrm{mol^{-1}\ dm^3\ s^{-1}}$

E20.23 0.43

E20.24 $R_0 = 3.5\bar{2}\ \mathrm{nm}$

E20.25 4×10^{-10} s or 0.4 ns

CHAPTER 21

Spectroscopy: Magnetic Resonance

E21.1 4.64×10^{-24} J

E21.2 $-1.300\times10^{-26}\ \mathrm{J}\times m_I$

E21.3 (a) $\mathrm{T^{-1}Hz}$
(b) $\mathrm{As\ kg^{-1}}$

E21.4 2.263

E21.5 (a) 8.96×10^{-4}
(b) 2.69×10^{-3}

E21.6 $\nu = 9.248$ GHz
$\lambda = 0.0324$ m

E21.7 (a) 2.9×10^{-5}
(b) 7.3×10^{-6}

E21.8 300.5 MHz

E21.9 43.69 MHz

E21.10 18.79 T

E21.11 3.17 kHz

E21.12 (a) 9.1 μT
(b) 38 μT

E21.13 (a) 2.4 kHz
(b) 6.0 kHz

E21.14 1 : 7 : 21 : 35 : 35 : 21 : 7 : 1

E21.15 (a) quintet1 : 2 : 3 : 2 : 1
(b) septet1 : 3 : 6 : 7 : 6 : 3 : 1

E21.22 $2.6\times10^{3}\ \mathrm{s}^{-1}$

E21.23 $[\mathrm{I}]_0 = \dfrac{[\mathrm{E}]_0\,\Delta\nu}{\delta\nu} - K_\mathrm{I}$

E21.24 2.0022

E21.25 $2.002\overline{5}$

E21.27 (a) 331.9 mT
(b) 1.201T

CHAPTER 22

Statistical Thermodynamics

ES22.1 0.37

E22.2 (a) 0.9999895
(b) 0.9998955

E22.3 0.99849

E22.4 1.753

E22.5 2.27

E22.6 (a) $1+6\mathrm{e}^{-2\varepsilon/kT}+3\mathrm{e}^{-5\varepsilon/kT}$
(b) $q=1$
(c) 10

E22.7 (a) 1.29
(b) 7.82

E22.8 (a) 5
(b) 6.731

E22.9 T = 17762 K

E22.10 (a) 1.401
(b) 3.147

E22.12 (a) 3.2×10^{4}
(b) 6.2×10^{27}

E22.13 (a) 24.816
(b) 24.480

E22.14 T = 38.96 K

E22.15 (a) 19.5
(b) 265

E22.17 $1+5\mathrm{e}^{-\varepsilon/kT}+3\mathrm{e}^{-3\varepsilon/kT}$

E22.20 $11.5\ \mathrm{J\,K^{-1}\,mol^{-1}}$

E22.21 $9.57\times10^{-15}\ \mathrm{J\,K^{-1}}$

E22.22 $191.4\ \mathrm{J\,K^{-1}\,mol^{-1}}$

E22.23 (a) $S^{\ominus}(\mathrm{Xe}) > S^{\ominus}(\mathrm{Ne})$
(b) $S^{\ominus}(\mathrm{D_2O}) > S^{\ominus}(\mathrm{H_2O})$.
(c) $S^{\ominus}(\mathrm{Graphite}) > S^{\ominus}(\mathrm{Diamond})$

E22.24 $40\ \mathrm{kJ\,K^{-1}\,mol^{-1}}$

E22.25 $-56.9\ \mathrm{kJ\,mol^{-1}}$

E22.26 $K = \dfrac{(q^{\ominus}_{\mathrm{NH_3,m}}/\mathrm{N_A})^2}{(q^{\ominus}_{\mathrm{N_2,m}}/\mathrm{N_A})(q^{\ominus}_{\mathrm{H_2,m}}/\mathrm{N_A})^3}\mathrm{e}^{-\Delta E/RT}$

E22.27 1.37×10^{-25}

E22.28 1.93×10^{-11}