Solutions to a) exercises

Please note that just the numerical and short-answer solutions are supplied. For full worked solutions to all of the (a) exercises, please refer to the *Solutions Manual* by Charles Trapp, Marshall Cady, and Carmen Giunta (9780198701286).

Topic 1

E1.1a

	Example	Element	Ground-state electronic configuration
(a)	Group 2	Ca, calcium	$[Ar]4s^2$
(b)	Group 7	Mn, manganese	$[Ar]3d^5 4s^2$
(c)	Group 15	As, arsenic	$[Ar]3d^{10}4s^2 4p^3$

E1.2a (a) Chemical formula and name: $MgCl_2$, magnesium chloride. Ions: Mg^{2+} and Cl^-. Oxidation numbers of the elements: magnesium, +2; chlorine, –1.

(b) Chemical formula and name: FeO, iron(II) oxide. Ions: Fe^{2+} and O^{2-}. Oxidation numbers of the elements: iron, +2; oxygen, –2.

(c) Chemical formula and name: Hg_2Cl_2, mercury(I) chloride. Ions: Cl^- and Hg_2^{2+} (a polyatomic ion). Oxidation numbers of the elements: mercury, +1; chlorine, –1.

E1.8a
(a) CO_2 is a linear, nonpolar molecule.
(b) SO_2 is a bent, polar molecule.
(c) N_2O is linear, polar molecule.
(d) SF_4 is a seesaw molecule and it is a polar molecule.

E1.9a In the order of increasing dipole moment: CO_2, N_2O, SF_4, SO_2.

E1.10a
(a) Mass is an extensive property.
(b) Mass density is an intensive property.
(c) Temperature is an intensive property.
(d) Number density is an intensive property.

E1.11a (a) 0.543 mol (b) 3.27×10^{23} molecules

E1.12a (a) 108. g (b) 1.77 N

E1.13a 0.43 bar

E1.14a 0.42 atm

E1.15a (a) 1.47×10^5 Pa (b) 1.47 bar

E1.16a $T = 310.2$ K

E1.17a $\theta/°\mathrm{C} = \frac{5}{9} \times (\theta_\mathrm{F}/°\mathrm{F} - 32)$ or $\theta_\mathrm{F}/°\mathrm{F} = \frac{9}{5} \times \theta/°\mathrm{C} + 32$

$\theta_\mathrm{F} = 173$ °F

$\theta_\mathrm{R} = 491.67$ °R

E1.18a 105 kPa

E1.19a S_8

E1.20a 1.8 MPa

E1.21a 4.6×10^5 Pa, 6.9×10^5 Pa

Topic 2

E2.1a (a) 9.81 ms^{-1}, 48 mJ (b) 29.4 ms^{-1}, 0.43 J

E2.2a $s_{\text{terminal}} = \dfrac{ze\mathcal{E}}{6\pi\eta R}$

E2.5a $1.0\,\hbar$

E2.6a (a) 2.25×10^{-20} J (b) 9.00×10^{-20} J

E2.7a 1.88×10^8 m s^{-1}, 100 keV

E2.8a 1.15×10^{-18} J, 1.48×10^{-20} J

E2.9a −2.40 V

E2.10a 24.1 kJ, 28.8 °C

E2.11a 27.2 K or 27.2 °C

E2.12a 128 J

E2.13a 2.4194 J K^{-1} g^{-1}

E2.14a 75.3 J K^{-1} mol^{-1}

E2.15a 8.3145 kJ mol^{-1}

E2.16a $S_{H_2O(g)} > S_{H_2O(l)}$

E2.17a $S_{Fe(3000\,K)} > S_{Fe(300\,K)}$

E2.19a (a) 1.6×10^{-17} (b) 0.021

E2.21a 4.631×10^{-6}

E2.23a 1.07

E2.24a 1.25

E2.25a 0.47 kJ

E2.26a (a) 1.38 kJ (b) 4.56 kJ

E2.27a 12.47 J mol^{-1} K^{-1}

E2.28a (a) 20.79 J mol^{-1} K^{-1} (b) 24.94 J mol^{-1} K^{-1}

Topic 3

E3.1a 2.26×10^{8} m s^{-1}

E3.2a 4.00 μm, 7.50×10^{13} Hz

Topic 4

E4.1a (a) 33 zJ, 20 kJ mol^{-1} (b) 3.3×10^{-34} J, 0.20 nJ mol^{-1}

E4.2a (a) No kinetic energy and zero speed (b) 0.452 aJ, 996 km s^{-1}

E4.3a 2.23 μm

E4.4a 6.96 keV without a relativist mass correction; 6.96 keV with the relativistic mass correction

The relativistic mass correction did not make a difference in this exercise.

E4.6a (a) 3.0×10^{19} s^{-1} (b) 7.4×10^{20} s^{-1}

E4.7a (a) 3.3×10^{-29} m (b) 1.3×10^{-36} m (c) 99.7 pm

E4.8a 7.27×10^{6} m s^{-1}, 150 V

E4.9a 1.71×10^{6} m s^{-1}

Topic 5

E5.3a $N = \left(\frac{1}{2\pi}\right)^{1/2}$

E5.4a $(1/2\pi)\,\mathrm{d}\varphi$

E5.5a $\frac{1}{2}$

Topic 6

E6.1a $\hat{V} = \frac{1}{2}k_{\mathrm{f}}x^2$

E6.2a -4

E6.3a (a) $\mathrm{i}k$ (b) not an eigenfunction of d/dx (c) not an eigenfunction of d/dx (d) not an eigenfunction of d/dx (e) not an eigenfunction of d/dx (f) not an eigenfunction of d/dx

Topic 7

E7.3a $\frac{L}{2}$

E7.4a 0

Topic 8

E8.1a 52 pm

E8.2a (a) $1.1\times10^{-28}\ \mathrm{m\,s^{-1}}$ (b) $1\times10^{-27}\ \mathrm{m}$

E8.3a (a) 0 (b) 0 (c) $\mathrm{i}\hbar$ (d) $2\mathrm{i}x\hbar$ (e) $n\mathrm{i}x^{n-1}\hbar$

Topic 9

E9.1a $3\times10^{-34}\ \mathrm{kg\,m\,s^{-1}}$, $5\times10^{-38}\ \mathrm{J}$

E9.2a $Ae^{\mathrm{i}kx}$, $2.7\times10^{33}\ \mathrm{m^{-1}}$

E9.3a (a) 1.8×10^{-19} J, 1.1×10^{2} kJ mol^{-1}, 1.1 eV, 9.1×10^{3} cm^{-1} (b) 6.6×10^{-19} J, 4.0×10^{2} kJ mol^{-1}, 4.1 eV, 3.3×10^{4} cm^{-1}

E9.4a (a) 0.04 (b) 0

E9.5a $\frac{h^2}{4L^2}$

E9.6a $\frac{\lambda_C}{8^{1/2}}$

E9.7a $x = \frac{L}{10}, \frac{3L}{10}, \frac{L}{2}, \frac{7L}{10}$, and $\frac{9L}{10}$

Topic 10

E10.1a 0.8

Topic 11

E11.1a (a) 3.6×10^{-19} J, 2.2×10^{2} kJ mol^{-1}, 2.3 eV, 1.8×10^{4} cm^{-1} (b) 1.3×10^{-18} J, 8.0×10^{2} kJ mol^{-1}, 8.3 eV, 6.7×10^{4} cm^{-1}

E11.2a (a) 5.5×10^{14} s^{-1}, 5.5×10^{-7} m, 550 nm (b) 2.0×10^{15} s^{-1}, 1.5×10^{-7} m, 150 nm

E11.3a (a) 5.5×10^{3} K (b) $3.\overline{3}\times10^{3}$ K

E11.4a (a) 0.0016 (b) 0

E11.5a (1/8, 1/10), (1/8, 3/10), (1/8, 1/2), (1/8, 7/10), (1/8, 9/10)

(3/8, 1/10), (3/8, 3/10), (3/8, 1/2), (3/8, 7/10), (3/8, 9/10)

(5/8, 1/10), (5/8, 3/10), (5/8, 1/2), (5/8, 7/10), (5/8, 9/10)

(7/8, 1/10), (7/8, 3/10), (7/8, 1/2), (7/8, 7/10), (7/8, 9/10)

E11.6a $\frac{x}{L} = 0, \frac{1}{2}, 1$, $\frac{y}{L} = 0, \frac{1}{3}, \frac{2}{3}, 1$

E11.7a $\frac{h^2}{2L^2}$

E11.8a $\frac{h}{2m_e c}, \frac{\lambda_C}{2}$

E11.10a 3

E11.11a 0.23 or 23 per cent

E11.12a $n = 9.77\times10^{10}$, 1.27×10^{-31} J, m = 25.8 pm

Topic 12

E12.1a 1.61×10^{-20} J

E12.2a 278 N m^{-1}

E12.3a 2.63 μm

E12.4a 3.72 μm

E12.5a $\pm0.525\alpha$ or $\pm1.65\alpha$

E12.7a 565 cm^{-1}

E12.8a 0.056

E12.9a $\langle E_k\rangle = 3\langle V\rangle/2$

Topic 13

n/a

Topic 14

E14.1a 1.49×10^{-34} J s, 0 or $\pm\hbar$

E14.2a (a) π/4 radians or 45° (b) π/2 radians or 90°

E14.3a 7

Topic 15

E15.1a 0

E15.2a $\frac{\varepsilon}{2}$

E15.3a $\frac{\varepsilon}{2}$

E15.4a 0

E15.5a $-\frac{mg^2}{2\omega^2}$

Topic 16

E16.1a 4.50×10^{-16} J m^{-3} s

Topic 17

E17.2a 14.0 eV

E17.3a $N=\frac{2}{a_0^{3/2}}$

E17.4a $r=4a_0$, $r=0$

E17.5a $r = 6a_0 = 3.175\times10^{-10}$ m

Topic 18

E18.1a (a) $l=0$, so angular momentum $=0$ (b) $l=1$, so angular momentum $=\sqrt{2}\hbar$ (c) $l=3$, so angular momentum $=2\sqrt{3}\hbar$

E18.2a 4

E18.3a (a) $g=1$ (b) $g=4$ (c) $g=16$

E18.4a $2E_{1s}$, $-E_{1s}$, –17.4376 aJ, 8.7188 aJ

E18.5a $\langle r_{2s}\rangle=\frac{6a_0}{Z}$, $r^*=(3+\sqrt{5})\frac{a}{Z}$

E18.6a $P_{3s}=4\pi r^2\left(\frac{1}{4\pi}\right)\times\left(\frac{1}{243}\right)\times\left(\frac{Z}{\alpha_0}\right)^3\times(6-6\rho+\rho^2)^2\mathrm{e}^{-\rho}$, $r = 0.74a_0/Z, 4.19a_0/Z,$ and $13.08a_0/Z$

E18.7a p_z orbital: The nodal plane is the *xy* plane and $\theta=\pi/2$ is an angular node.
p_x orbital: The nodal plane is the *yz* plane and $\theta=0$ is an angular node.
p_y orbital: The nodal plane is the *xz* plane and $\theta=0$ is an angular node.

Topic 19

E19.1a $8.89\times10^{10}\ \mathrm{m\,s^{-1}}$

Topic 20

E20.2a Sc: $[Ar]4s^23d^1$
Ti: $[Ar]4s^23d^2$
V: $[Ar]4s^23d^3$
Cr: $[Ar]4s^23d^4$ or $[Ar]4s^13d^5$ (most probable)
Mn: $[Ar]4s^23d^5$
Fe: $[Ar]4s^23d^6$
Co: $[Ar]4s^23d^7$
Ni: $[Ar]4s^23d^8$
Cu: $[Ar]4s^23d^9$ or $[Ar]4s^13d^{10}$ (most probable)
Zn: $[Ar]4s^23d^{10}$

Topic 21

E21.1a 9.118×10^{-6} cm, 1.216×10^{-5} cm

E21.2a $\tilde{\nu} = 3.292\times10^{5}\ \mathrm{cm^{-1}}$, $\lambda = 3.038\times10^{-6}\mathrm{cm}$, $\nu = 9.869\times10^{15}\ \mathrm{s^{-1}}$

E21.3a (a) forbidden (b) allowed (c) allowed

E21.4a (a) $[Kr]4d^8$ (b) $S = 1, 0$; $M_S = -1, 0, +1$; $M_S = 0$

E21.5a (a) $\frac{5}{2}, \frac{3}{2}$ (b) $\frac{7}{2}, \frac{5}{2}$

E21.6a $l = 3$ or 2, $l = 1$ or 0

E21.7a $J = 3, 2, 1$

E21.8a $L = 1,\ S = 1,\ J = 2$

E21.9a (a) $1, 0$ with multiplicities $3, 1$, respectively (b) $S = \frac{3}{2}, \frac{1}{2}$ [from 1], and $\frac{1}{2}$ [from 0], with multiplicities $4, 2, 2$

E21.10a $^3D_3$, $^3D_2$, $^3D_1$, $^1D_2$, ^3D set of terms are the lower in energy

E21.11a (a) $J = 1$ ($^3S_1$) and there are 3 states (b) $J = \frac{5}{2}, \frac{3}{2}$, respectively ($^2D_{5/2}$, $^2D_{3/2}$), with 6, and 2 states, respectively (c) $J = 1$ ($^1P_1$) with 3 states

E21.12a (a) $^2S_{1/2}$ (b) $^2D_{5/2}$ and $^2D_{3/2}$

Topic 22

E22.1a $\{s(1)p_z(2)+s(2)p_z(1)\} \times \{\alpha(1)\beta(2)-\alpha(2)\beta(1)\}$

E22.2a $\psi = a\psi_{\mathrm{VB}} + b\psi_{\mathrm{H^-F^+}} + c\psi_{\mathrm{H^+F^-}}$

E22.6a $N = 3^{-1/2}$, $\psi = 3^{-1/2}(\mathrm{s} + 2^{1/2}\mathrm{p})$

Topic 23

E23.1a $N = \left(\dfrac{1}{1+2\lambda S+\lambda^2}\right)^{1/2}$

E23.2a $N = 1.12$, $\psi_1 = 0.163A + 0.947B$, $b = 0.412$, $a = -1.02$, $\psi_2 = -1.02A + 0.412B$

E23.3a 1.9 eV, 130 pm

E23.4a The bonding orbital is odd (u) and the antibonding orbital is even (g).

Topic 24

24.1a (a) $1\sigma_g^2$, $b = 1$ (b) $1\sigma_g^2 1\sigma_u^2$, $b = 0$ (c) $1\sigma_g^2 1\sigma_u^2 1\pi_u^4$, $b = 2$

24.2a C_2

24.3a F_2^+

24.4a $b = 1$, $b = 0$, $b = 1$, $b = 2$, $b = 3$, $b = 2$, $b = 1$

24.5a $2\pi_g$

24.6a $4\times10^5\ \mathrm{m\,s^{-1}}$

24.7a (a) 2.1×10^{-10} m = 0.21 nm (b) 1.0×10^{-10} m = 0.10 nm

Topic 25

E25.1a (a) $1\sigma^2 2\sigma^2 1\pi^4 3\sigma^2$ (b) $1\sigma^2 2\sigma^2 3\sigma^2 1\pi^4 2\pi^1$ (c) $1\sigma^2 2\sigma^2 1\pi^4 3\sigma^2$

E25.3a NO^+

E25.5a 7.2, 8.3

E25.6a –6.6 or –8.9

E25.7a –5.0 or –10.7 eV

Topic 26

E26.1a (a) $\begin{vmatrix} \alpha - E & \beta & 0 \\ \beta & \alpha - E & \beta \\ 0 & \beta & \alpha - E \end{vmatrix}$ (b) $\begin{vmatrix} \alpha - E & \beta & \beta \\ \beta & \alpha - E & \beta \\ \beta & \beta & \alpha - E \end{vmatrix}$

E26.2a (a) $C_6H_6^-$ (7 electrons): $a_{2u}^2 e_{1g}^4 e_{2u}^1$ $E_\pi = 2(\alpha + 2\beta) + 4(\alpha + \beta) + (\alpha - \beta) = 7\alpha + 7\beta$

(b) $C_6H_6^+$ (5 electrons): $a_{2u}^2 e_{1g}^3$ $E_\pi = 2(\alpha + 2\beta) + 3(\alpha + \beta) = 5\alpha + 7\beta$

E26.3a (a) 7β, 0 (b) 7β, 2β

E26.5a (a) $14\alpha + 19.314\beta$ (b) $14\alpha + 19.448\beta$

Topic 27

E27.1a $\hat{V} = -3j_0\left\{\frac{1}{r_{\text{Li1}}} + \frac{1}{r_{\text{Li2}}} + \frac{1}{r_{\text{Li3}}} + \frac{1}{r_{\text{Li4}}}\right\} - j_0\left\{\frac{1}{r_{\text{H1}}} + \frac{1}{r_{\text{H2}}} + \frac{1}{r_{\text{H3}}} + \frac{1}{r_{\text{H4}}}\right\} + j_0\left\{\frac{1}{r_{12}} + \frac{1}{r_{13}} + \frac{1}{r_{14}} + \frac{1}{r_{23}} + \frac{1}{r_{24}} + \frac{1}{r_{34}}\right\}$

E27.2a $N_e = 2$ for HeH^+, $\hat{H} = -\frac{\hbar^2}{2m_e}\left\{\nabla_1^2 + \nabla_2^2\right\} - 2j_0\left\{\frac{1}{r_{\text{He1}}} + \frac{1}{r_{\text{He2}}}\right\} - j_0\left\{\frac{1}{r_{\text{H1}}} + \frac{1}{r_{\text{H2}}}\right\} + j_0\left\{\frac{1}{r_{12}}\right\}$

E27.3a $N_e = 2$ for HeH^+, $\Psi = \frac{1}{\sqrt{2}}\begin{vmatrix} \psi_a{}^\alpha(1) & \psi_a{}^\beta(1) \\ \psi_a{}^\alpha(2) & \psi_a{}^\beta(2) \end{vmatrix}$

E27.4a $f_1\psi_a(1) = h_1\psi_a(1) + J_a(1)\psi_a(1) = \varepsilon_a\psi_a(1)$

E27.6a $F_{\text{AA}} = E_{\text{He}} + c_{\text{Hea}}^2(\text{HeHe}|\text{HeHe}) + 2c_{\text{Hea}}c_{\text{Ha}}(\text{HeHe}|\text{HeH}) + c_{\text{Ha}}^2\{2(\text{HeHe}|\text{HH}) - (\text{HeH}|\text{HeH})\}$

$F_{\text{AB}} = \int \chi_{\text{He}}(1)h_1\chi_{\text{H}}(1)\text{d}\tau_1 + c_{\text{Hea}}^2(\text{HeH}|\text{HeHe}) + c_{\text{Hea}}c_{\text{Ha}}\{3(\text{HeH}|\text{HeH}) - (\text{HeHe}|\text{HH})\} + c_{\text{Ha}}^2(\text{HeH}|\text{HH})$

E27.8a (a) 17 basis functions (b) 28 basis functions (c) 34 basis functions

Topic 28

E28.1a $c_{\text{Ha}} = \left(\frac{1}{1 + \left(\frac{\beta}{\alpha_{\text{He}} - \varepsilon_a}\right)^2}\right)^{1/2}$, $\varepsilon_a = \frac{\alpha_{\text{He}} + \alpha_{\text{H}} - \left(\{\alpha_{\text{He}} - \alpha_{\text{H}}\}^2 + 4\beta^2\right)^{1/2}}{2}$, $c_{\text{Ha}} = \left(\frac{1}{1 + \left(\frac{\beta}{\alpha_{\text{He}} - \varepsilon_a}\right)^2}\right)^{1/2}$

Topic 29

E29.2a $\Psi_1(1\text{ of }4) = (1/2)^{1/2}\begin{vmatrix}\psi_b^\alpha(1) & \psi_a^\beta(1)\\ \psi_b^\alpha(2) & \psi_a^\beta(2)\end{vmatrix}$, $\Psi_1(2\text{ of }4) = (1/2)^{1/2}\begin{vmatrix}\psi_a^\alpha(1) & \psi_b^\beta(1)\\ \psi_a^\alpha(2) & \psi_b^\beta(2)\end{vmatrix}$,

$\Psi_1(3\text{ of }4) = (1/2)^{1/2}\begin{vmatrix}\psi_a^\alpha(1) & \psi_b^\alpha(1)\\ \psi_a^\alpha(2) & \psi_b^\alpha(2)\end{vmatrix}$, $\Psi_1(4\text{ of }4) = (1/2)^{1/2}\begin{vmatrix}\psi_a^\beta(1) & \psi_b^\beta(1)\\ \psi_a^\beta(2) & \psi_b^\beta(2)\end{vmatrix}$,

$\Psi = C_0\Psi_0 + C_2\Psi_2 = C_0\begin{vmatrix}\psi_a^\alpha(1) & \psi_a^\beta(1)\\ \psi_a^\alpha(2) & \psi_a^\beta(2)\end{vmatrix} + C_2\begin{vmatrix}\psi_b^\alpha(1) & \psi_b^\beta(1)\\ \psi_b^\alpha(2) & \psi_b^\beta(2)\end{vmatrix}$

E29.3a

$$\Psi = C_0\Psi_0 + C_1\{\Psi_1(1\text{ of }2) + \Psi_1(2\text{ of }2)\} = C_0\begin{vmatrix}\psi_a^\alpha(1) & \psi_a^\beta(1)\\ \psi_a^\alpha(2) & \psi_a^\beta(2)\end{vmatrix} + C_1\left\{\begin{vmatrix}\psi_b^\alpha(1) & \psi_a^\beta(1)\\ \psi_b^\alpha(2) & \psi_a^\beta(2)\end{vmatrix} + \begin{vmatrix}\psi_a^\alpha(1) & \psi_b^\beta(1)\\ \psi_a^\alpha(2) & \psi_b^\beta(2)\end{vmatrix}\right\}$$

E29.4a

$$\begin{aligned}\int \Psi_2 \hat{H}^{(1)} \Psi_0 \,\mathrm{d}\tau = {} & c_{\mathrm{Hea}}^2 c_{\mathrm{Heb}}^2 (\mathrm{HeHe|HeHe}) + 2\left(c_{\mathrm{Hea}}^2 c_{\mathrm{Heb}} c_{\mathrm{Hb}} + c_{\mathrm{Hea}} c_{\mathrm{Ha}} c_{\mathrm{Heb}}^2\right)(\mathrm{HeH|HeHe}) \\ & + \left(c_{\mathrm{Hea}}^2 c_{\mathrm{Hb}}^2 + 2c_{\mathrm{Hea}} c_{\mathrm{Ha}} c_{\mathrm{Heb}} c_{\mathrm{Hb}} + c_{\mathrm{Ha}}^2 c_{\mathrm{Heb}}^2\right)(\mathrm{HeH|HeH}) + 2c_{\mathrm{Hea}} c_{\mathrm{Ha}} c_{\mathrm{Heb}} c_{\mathrm{Hb}} (\mathrm{HH|HeHe}) \\ & + 2\left(c_{\mathrm{Ha}}^2 c_{\mathrm{Heb}} c_{\mathrm{Hb}} + c_{\mathrm{Hea}} c_{\mathrm{Ha}} c_{\mathrm{Hb}}^2\right)(\mathrm{HH|HHe}) + c_{\mathrm{Ha}}^2 c_{\mathrm{Hb}}^2 (\mathrm{HH|HH})\end{aligned}$$

Topic 30

E30.2a $2\left\{|\psi_a(\boldsymbol{r})|^2 + |\psi_b(\boldsymbol{r})|^2\right\}$

Topic 31

E31.1a The elements, other than the identity E, are a C_3 axis and three vertical mirror planes σ_v

E31.2a There are $3C_2$ axes, a centre of inversion, and $3\sigma_h$ mirror planes

E31.3a (a) Sphere: an infinite number of symmetry axes; therefore R_3 (b) Isosceles triangles: E, C_2, σ_v, and σ_v'; therefore C_{2v} (c) D_{3h} (d) $D_{\infty h}$

E31.4a (a) C_{2v} (b) $C_{\infty v}$ (c) C_{3v} (d) D_{2h}

E31.5a (a) C_{2v} (b) C_{2h}

E31.6a (a) pyridine (C_{2v}) and (b) nitroethane (C_s) are polar

E31.8a D_{2h} contains i and C_{3h} contains σ_h

Topic 32

E32.1a $\boldsymbol{D}(\sigma_h) = \begin{pmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}$

E32.2a $\begin{pmatrix} -1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \\ 0 & -1 & 0 & 0 \end{pmatrix} = \boldsymbol{D}(S_3)$

E32.4a 3

E32.5a 2

Topic 33

E33.1a Integral must be zero

E33.4a No N orbitals, d_{xy}

E33.6a $2A_1 + B_1 + E$

E33.7a (a) either E_{1u} or A_{2u} (b) B_{3u} (x-polarized), B_{2u} (y-polarized), B_{1u} (z-polarized)

Topic 34

E34.1a ClF_3, O_3, H_2O_2

E34.2a 2.8 D

E34.3a –36.1 D, –7.54 D, 36.9 D, 168°

E34.4a 2.19×10^{-36} C m, 0.658 μD

Topic 35

E35.1a 1.07×10^{3} kJ mol^{-1}

E35.2a $\dfrac{6l^4Q_1^2}{\pi\varepsilon_0 r^5}$

E35.3a $28\overline{9}$ kJ mol^{-1}

Topic 36

E36.1a $1.24\,\text{bar}$, $1.24\,\text{bar}$

E36.2a $2.75\,\text{bar}$

E36.3a (a) $25\,\text{bar}$ (b) $22\,\text{bar}$

E36.4a $7.61\times10^{-2}\,\text{kg m}^5\,\text{s}^{-2}\,\text{mol}^{-2}$, $2.26\times10^{-5}\,\text{m}^3\,\text{mol}^{-1}$

E36.5a (a) 0.92 (b) $1.6\,\text{dm}^3\,\text{mol}^{-1}$, attractive forces dominate

E36.6a 140 atm

E36.7a $1.41\times10^3\,\text{K}$

E36.8a 175 pm

E36.9a $0.046\,\text{dm}^3\,\text{mol}^{-1}$

E36.10a 0.66

Topic 37

E37.1a $N=4$, $4.01\,\text{g cm}^{-3}$

E37.2a (323) and (110)

E37.3a 229 pm, 397 pm, 115pm

E37.4a 220 pm

E37.5a 291 pm, 10.1°, 14.4°, 17.7°

E37.6a $8.16°$, $4.82°$, $11.7\overline{5}°$

E37.7a $2.14°$

E37.8a $f_{\text{Br}^-}=36$

E37.9a f

E37.10a $3f$ for $h+k$ even and $-f$ for $h+k$ odd

E37.14a $6.1\,\text{km s}^{-1}$

E37.15a 233 pm

Topic 38

E38.1a 0.9069

E38.2a (a) 0.5236 (b) 0.6802 (c) 0.7405

E38.3a (a) 74.9 pm (b) 132 pm

E38.4a Expansion

E38.5a $3500\ \text{kJ mol}^{-1}$

Topic 39

E39.1a 3.54 eV

E39.2a Three unpaired spins

E39.3a $-6.4\times10^{-5}\ \text{cm}^3\,\text{mol}^{-1}$, $-6.4\times10^{-11}\ \text{m}^3\ \text{mol}^{-1}$

E39.4a 4.326, 5

E39.5a $+1.6\times10^{-8}\ \text{m}^3\ \text{mol}^{-1}$

Topic 40

E40.1a 82.9 per cent

E40.2a $5.34\times10^{3}\ \text{dm}^3\ \text{mol}^{-1}\ \text{cm}^{-1}$

E40.3a $1.09\ \text{mmol dm}^{-3}$

E40.4a $1.3\times10^{8}\ \text{dm}^3\ \text{mol}^{-1}\ \text{cm}^{-2}$

E40.5a $450\ \text{dm}^3\ \text{mol}^{-1}\ \text{cm}^{-2}$

E40.6a $15\overline{9}\ \text{dm}^3\ \text{mol}^{-1}\ \text{cm}^{-1}$, 23 per cent

E40.7a (a) 0.87 m (b) 2.9 m

E40.8a $0.9999\times\lambda$

E40.9a (a) 27 ps (b) 2.7 ps

E40.10a (a) $\delta\tilde{\nu} = 53\ \text{cm}^{-1}$ (b) $\delta\tilde{\nu} = 0.53\ \text{cm}^{-1}$

Topic 41

E41.1a $6.33\times10^{-46}\,\text{kg m}^2$, $0.4421\,\text{cm}^{-1}$

E41.3a (a) asymmetric (b) oblate symmetric (c) spherical (d) prolate symmetric

E41.4a 106.5 pm, 115.6 pm

Topic 42

E42.2a 3.07×10^{11} Hz

E42.3a 127.4 pm

E42.4a $4.442\times10^{-47}\,\text{kg m}^2$, 165.9 pm

E42.5a (c) CH_4 is inactive.

E42.6a $20\,475\,\text{cm}^{-1}$

E42.7a 198.9 pm

E42.8a $\frac{5}{3}$

Topic 43

E43.1a $16\,\text{N m}^{-1}$

E43.2a 1.077 percent

E43.3a $328.7\,\text{N m}^{-1}$

E43.4a 967.0, 515.6, 411.8, 314.2

E43.5a $1580.38\,\text{cm}^{-1}$, 7.644×10^{-3}

Topic 44

E44.1a (b) HCl (c) CO_2 (d) H_20

E44.2a (a) 3 (b) 6 (c) 12

E44.3a 127

E44.4a $\frac{1}{2}(\tilde{\nu}_1+\tilde{\nu}_2+\tilde{\nu}_3)$

E44.5a (a) Nonlinear: all modes are both infrared and Raman active. (b) Linear: the symmetric stretch is infrared inactive but Raman active.

E44.6a Raman active

E44.7a $4A_1 + A_2 + 2B_1 + 2B_2$

E44.8a A_1, B_1 and B_2 are infrared active; all modes are Raman active.

Topic 45

E45.1a 3, u

E45.2a (a) allowed (b) allowed (c) forbidden (d) forbidden (e) allowed

E45.3a $\frac{2\sqrt{2}}{3} e^{-2\alpha x_0^2/3}$

E45.4a $\frac{1}{32}\left(3+\frac{4}{\pi}\right)^2$

E45.5a $\frac{1}{2}\left(\tilde{B}'+\tilde{B}\right)/\left(\tilde{B}'-\tilde{B}\right)$

E45.6a $\frac{1}{2}\left(\tilde{B}'+\tilde{B}\right)/\left|\left(\tilde{B}'-\tilde{B}\right)\right| -1$, 7

E45.7a $30.4\ \text{cm}^{-1} < \tilde{B}' < 40.5\ \text{cm}^{-1}$, greater

E45.8a $\Delta_O = P - \tilde{\nu}$, $14 \times 10^3\ \text{cm}^{-1}$

E45.9a $\frac{3}{8}\left(\frac{a^3}{b - \frac{1}{2}a}\right)^{1/2}$

E45.10a $\frac{1}{4} e^{-1/16} a$

Topic 46

E46.1a (a) lower, $\tilde{\nu} \approx 1800\,\text{cm}^{-1}$ (b) no information

E46.3a 20 ps, 70 MHz

Topic 47

E47.1a $s^{-1}\ T^{-1}$

E47.2a 9.133×10^{-35} J s, ±0.9553 rad $= \pm54.74^\circ$

E47.3a 574 MHz

E47.4a -1.473×10^{-26} J $\times m_I$

E47.5a 165 MHz

E47.6a (a) 3.98×10^{-25} J (b) 6.11×10^{-26} J, thus the separation in energy is larger for the proton (a).

E47.7a 16.25 T

E47.9a (a) 1×10^{-6} (b) 5.1×10^{-6} (c) 3.4×10^{-5}

E47.10a 13

E47.11a (a) 2×10^{2} T (b) 10 mT

Topic 48

E48.1a (a) independent (b) 13

E48.2a (a) 11 μT (b) 110 μT

E48.5a 753 MHz

E48.7a 0.39 ms, $2.6\times10^{3}\,s^{-1}$

Topic 49

E49.1a 5.9×10^{-4} T, 20 μs

Topic 50

E50.1a 2.0022

E50.2a 2.3 mT, $2.002\overline{5}$

E50.3a equal intensity, 330.2 mT, 332.2 mT, 332.8 mT, 334.8 mT

E50.5a (a) 332.3 mT (b) 1.206 T

E50.6a $I = \frac{3}{2}$

Topic 51

E51.1a 21 621 600

E51.2a (a) 40 320 (b) 5.63×10^3 (c) 3.99×10^4

E51.3a 1

E51.4a 524 K

E51.5a 7.43

E51.6a $35\overline{4}$ K

Topic 52

E52.1a (a) (i) 8.23 pm (ii) 2.60 pm (b) (i) 1.79×10^{27} (ii) 5.67×10^{28}

E52.2a 0.3574

E52.3a 72.2

E52.4a (a) 7.97×10^3 (b) 1.12×10^4

E52.5a 18 K

E52.6a 37 K

E52.7a 4.5 K

E52.8a (a) 1 (b) 2 (c) 2 (d) 12 (e) 3

E52.9a 660.6

E52.10a 4500 K

E52.11a 2.571

E52.12a 42.3

E52.13a 4.292, 0.0353 to 0.0377 to 1

Topic 53

E53.1a 8.16×10^{-22} J

E53.2a 18.5 K

E53.3a 25 K

E53.4a 4.5 K

E53.5a 4600 K

E53.6a 10 500 K

E53.7a 6500 K

E53.8a 4.033×10^{-21} J

Topic 54

E54.1a (a) He gas (b) CO gas (c) H_2O vapour

Topic 55

E55.1a (a) $\frac{7}{2}R$, $8.671\ \text{kJ mol}^{-1}$ (b) $3R$, $7.436\ \text{kJ mol}^{-1}$ (c) $7R$, $17.35\ \text{kJ mol}^{-1}$

E55.2a (a) pressure, (b) temperature, and (d) enthalpy are state functions.

E55.3a 3.5×10^{3} J needed, 5.7×10^{2} J needed

E55.4a $-75\,\text{J}$

E55.5a (a) $-2.68\,\text{kJ}$, $+2.68\,\text{kJ}$ (b) $-1.62\,\text{kJ}$, $+1.62\,\text{kJ}$ (c) $w=0$, 0

E55.6a $1.33\,\text{atm}$, $+1.25\,\text{kJ}$, $w=0$, $+1.25\,\text{kJ}$

Topic 56

E56.1a $30\ \text{J K}^{-1}\ \text{mol}^{-1}$, $22\ \text{J K}^{-1}\,\text{mol}^{-1}$

E56.2a (a) $+10.7$ kJ, -0.624 kJ, $+10.1\,\text{kJ}$ (b) $+10.7$ kJ, $+10.1\,\text{kJ}$, $+10.1\,\text{kJ}$

E56.3a (a) $+2.2$ kJ, $+2.2$ kJ, $+1.6\,\text{kJ}$

E56.4a $-7.2\ \text{J atm}^{-1}\,\text{mol}^{-1}$, $+6.1\,\text{kJ}$

Topic 57

E57.1a 22.5 kJ, -1.6 kJ, 20.9 kJ

E57.2a $-4564.7\,\text{kJ mol}^{-1}$

E57.3a $+53\ \text{kJ mol}^{-1}$, $-33\ \text{kJ mol}^{-1}$

E57.4a $-167\ \text{kJ mol}^{-1}$

E57.5a $-5152\ \text{kJ mol}^{-1}$, $1.58\ \text{kJ K}^{-1}$, $+3.08\,\text{K}$

E57.6a (a) $-114.40\ \text{kJ mol}^{-1}$, $-111.92\ \text{kJ mol}^{-1}$ (b) $-92.31\ \text{kJ mol}^{-1}$, $-241.82\ \text{kJ mol}^{-1}$

E57.7a $-1368\ \text{kJ mol}^{-1}$

E57.8a (a) $+131.29\ \text{kJ mol}^{-1}$, $+128.81\ \text{kJ mol}^{-1}$ (b) $+134.14\ \text{kJ mol}^{-1}$, $+130.17\ \text{kJ mol}^{-1}$

E57.9a $-803.07\ \text{kJ mol}^{-1}$

E57.10a $-1892\ \text{kJ mol}^{-1}$

Topic 58

E58.1a (a) 0.236 (b) 0.193

E58.2a

	$C_{V,\text{m}}$	$C_{p,\text{m}}$	γ	Exptl	
$NH_3(v_V^* = 0)$	$3R$	$4R$	1.33	1.31	closer
$NH_3(v_V^* = 6)$	$9R$	$10R$	1.11		
$CH_4(v_V^* = 0)$	$3R$	$4R$	1.33	1.31	closer
$CH_4(v_V^* = 9)$	$12R$	$13R$	1.08		

E58.3a 2.91×10^{-21} J

E58.4a $13\dot{1}$ K

E58.5a $0.00846\ \text{m}^3$, $257\ \text{K}$, -0.89×10^3 J

E58.6a $-194\,\text{J}$

E58.7a $9.7\,\text{kPa}$

E58.8a 5.03 mbar

E58.9a $+130.\dot{1}\ \text{J mol}^{-1}$, $+7.52\times10^3\,\text{J mol}^{-1}$, $-7.39\times10^3\,\text{J mol}^{-1}$

E58.10a $1.31\times10^{-3}\,\text{K}^{-1}$

E58.11a 2.0×10^{3} atm

Topic 59

E59.1a Not spontaneous

Topic 60

E60.1a (a) 126 $J\,K^{-1}\,mol^{-1}$ (b) 169 $J\,K^{-1}\,mol^{-1}$

E60.2a $T = 2.35\times10^{3}$ K

E60.3a 43.1, 22.36 K, 43.76 $J\,K^{-1}\,mol^{-1}$

E60.4a 54.72 $J\,K^{-1}\,mol^{-1}$

E60.5a 11.5 $J\,K^{-1}\,mol^{-1}$

E60.6a (a) 34.72 $J\,K^{-1}\,mol^{-1}$ (b) 119.06 $J\,K^{-1}\,mol^{-1}$

Topic 61

E61.1a $T_c = 191.2$ K

E61.2a (a) 366 $J\,K^{-1}$ (b) 309 $J\,K^{-1}$

Topic 62

E62.1a $I_2(g)$

E62.2a 3.1 $J\,K^{-1}$

E62.3a 30.0 $kJ\,mol^{-1}$

E62.4a 152.67 $J\,K^{-1}\,mol^{-1}$

E62.6a 0, 0

E62.7a $\Delta H = 0$, +2.7 $J\,K^{-1}$

E62.8a (a) +2.9 $J\,K^{-1}$, –2.9 $J\,K^{-1}$, 0 (b) +2.9 $J\,K^{-1}$, 0, +2.9 $J\,K^{-1}$ (c) 0, 0, 0

E62.9a (a) +87.8 $J\,K^{-1}\,mol^{-1}$ (b) –87.8 $J\,K^{-1}\,mol^{-1}$

E62.10a $\Delta S = 92.2\ \text{J K}^{-1}$

Topic 63

E63.1a (a) 9.13 J K^{-1} mol^{-1}, 13.4 J K^{-1} mol^{-1}, 14.9 J K^{-1} mol^{-1}

E63.2a (a) $-386.1\,\text{J K}^{-1}\,\text{mol}^{-1}$, (b) $+92.6\,\text{J K}^{-1}\,\text{mol}^{-1}$ (c) $-153.1\,\text{J K}^{-1}\,\text{mol}^{-1}$

Topic 64

E64.1a (a) $-521.5\ \text{kJ mol}^{-1}$ (b) $+25.8\ \text{kJ mol}^{-1}$ (c) $-178.7\ \text{kJ mol}^{-1}$

E64.2a $-480.98\ \text{kJ mol}^{-1}$

E64.3a $817.90\ \text{kJ mol}^{-1}$

E64.4a $-13.8\ \text{kJ mol}^{-1}$, $-0.20\ \text{kJ mol}^{-1}$

E64.5a (a) $-6.42\,\text{kJ mol}^{-1}$ (b) $-14.0\,\text{kJ mol}^{-1}$

Topic 65

E65.1a (a) $-522.1\ \text{kJ mol}^{-1}$ (b) $+25.78\ \text{kJ mol}^{-1}$ (c) $-178.6\ \text{kJ mol}^{-1}$

E65.2a $-340\ \text{kJ mol}^{-1}$

Topic 66

E66.1a $-17\,\text{J}$

E66.2a $-36.5\,\text{J K}^{-1}$

E66.3a $+10\,\text{kJ}$, $1.6\ \text{kJ mol}^{-1}$

E66.4a $+11\ \text{kJ mol}^{-1}$

E66.5a 12 kJ

Topic 67

E67.1a $P = 1$, $P = 3$

Topic 69

E69.1a $\mu_W(s) = \mu_W(l)$, $\mu_E(s) = \mu_E(l)$

E69.2a $-0.38\ \text{J mol}^{-1}$

E69.3a $-3 \times 10^2\ \text{J mol}^{-1}$

E69.4a $1.79 \times 10^5\ \text{J mol}^{-1}$

E69.5a $+45\ \text{J K}^{-1}\ \text{mol}^{-1}$, $+1.59 \times 10^4\ \text{J mol}^{-1} = +15.9\ \text{kJ mol}^{-1}$

E69.6a $+12487\ \text{J mol}^{-1} = +12.487\ \text{kJ mol}^{-1}$

E69.7a 37°C

E69.8a (a) $2.9\overline{7} \times 10^4\ \text{J mol}^{-1} = 29.\overline{7}\ \text{kJ mol}^{-1}$ (b) 0.169 bar, 0.82 bar

E69.9a –0.35°C, 272.80 K

Topic 70

E70.1a (a) $1.1 \times 10^3\ \text{g} = 1.1\text{kg}$ (b) $2.0 \times 10^4\ \text{g}$, $20.\text{kg}$

E70.2a $-1.0\overline{4}\ \text{kJ}$, $+3.5\ \text{J K}^{-1}$

E70.3a $-1.37 \times 10^3\ \text{J mol}^{-1} = -1.37\ \text{kJ mol}^{-1}$

E70.4a $\frac{1}{2}$, 0.4624, 0.5376

E70.5a 6.4×10^3 kPa

E70.6a 0.268, 0.732, 58.6 kPa

E70.7a 2.0×10^2 kPa

E70.8a $85\ \text{g mol}^{-1}$

E70.9a (a) $3.4 \times 10^{-3}\ \text{mol kg}^{-1}$ (b) $3.4 \times 10^{-2}\ \text{mol kg}^{-1}$

Topic 71

E71.1a $88.2\ \text{kg mol}^{-1}$

E71.2a (a) $18\ \text{kg mol}^{-1}$ (b) $20\ \text{kg mol}^{-1}$ (c) 1.1

Topic 72

E72.1a 2.8, phase separation does occur

E72.2a 0.833, $0.9\overline{3}$, 0.125, $1.2\overline{5}$, $2.\overline{8}$, $1.\overline{25}$

E72.3a 0.498, 0.667, 1.24, 1.11

E72.4a 0.694

E72.5a 1.55

E72.6a (a) 8.75 g (b) 9.35 g

E72.7a 0.0190, 0.72, 0.85

E72.8a 2.01

Topic 73

E73.1a (a) (i) $K = \dfrac{a_{\mathrm{COCl(g)}}a_{\mathrm{Cl(g)}}}{a_{\mathrm{CO(g)}}a_{\mathrm{Cl_2(g)}}}$ (ii) $K = \dfrac{p_{\mathrm{COCl}}p_{\mathrm{Cl}}}{p_{\mathrm{CO}}p_{\mathrm{Cl_2}}}$

(b) (i) $K = \dfrac{a^2_{\mathrm{SO_3(g)}}}{a^2_{\mathrm{SO_2(g)}}a_{\mathrm{O_2(g)}}}$ (ii) $K = \dfrac{p^2_{\mathrm{SO_3}}p^{\ominus}}{p^2_{\mathrm{SO_2}}p_{\mathrm{O_2}}}$

(c) (i) $K = \dfrac{a_{\mathrm{FeSO_4(aq)}}}{a_{\mathrm{PbSO_4(aq)}}}$ (ii) $K = \dfrac{\gamma_{\mathrm{FeSO_4}}}{\gamma_{\mathrm{PbSO_4}}} \times \dfrac{b_{\mathrm{FeSO_4}}}{b_{\mathrm{PbSO_4}}}$

(d) (i) $K = \dfrac{a^2_{\mathrm{HCl(aq)}}}{a_{\mathrm{H_2(g)}}}$ (ii) $K = \dfrac{\gamma^2_{\mathrm{HCl(aq)}}b^2_{\mathrm{HCl(aq)}}}{p_{\mathrm{H_2(g)}}} \times \dfrac{p^{\ominus}}{\left(b^{\ominus}\right)^2}$

(e) (i) $K = \dfrac{a_{\mathrm{CuCl_2(aq)}}}{a^2_{\mathrm{CuCl(aq)}}}$ (ii) $K = \dfrac{\gamma_{\mathrm{CuCl_2}}}{\gamma^2_{\mathrm{CuCl}}} \times \dfrac{b_{\mathrm{CuCl_2}}b^{\ominus}}{b^2_{\mathrm{CuCl}}}$

E73.2a $\nu_{\mathrm{Hg_2Cl_2}} = -1,\ \nu_{\mathrm{H_2}} = -1,\ \nu_{\mathrm{HCl}} = 2,\ \nu_{\mathrm{Hg}} = 2$

E73.3a +12.3 kJ mol^{-1}

E73.4a –11.20 kJ mol^{-1}

E73.5a –1108 kJ mol^{-1}

E73.6a (a) 0.087, 0.370, 0.196, 0.348, 1.001 (b) 0.33 (c) 0.33 (d) +2.8 kJ mol^{-1}

E73.7a –30 kJ mol^{-1}

Topic 74

74.1a 0.003 725

Topic 75

E75.1a K_x is reduced by 67 per cent

E75.2a 0.045, 1500 K

E75.3a $+3.47\ \text{kJ mol}^{-1}$, $-14.8\ \text{J K}^{-1}\ \text{mol}^{-1}$

E75.4a (a) $+53\ \text{kJ mol}^{-1}$ (b) $-53\ \text{kJ mol}^{-1}$

E75.5a 1110 K

E75.6a (a) $-68.26\ \text{kJ mol}^{-1}$, 9.2×10^{11} (b) $-63.99\ \text{kJ mol}^{-1}$, 1.3×10^{9}, $-69.7\ \text{kJ mol}^{-1}$

Topic 76

E76.1a (a) +0.80 V, –0.76 V, +1.56 V (b) 0, –0.40 V, +0.40 V (c) –0.74 V, +0.36 V, –1.10 V (d) +0.15 V, +0.77 V, –0.62 V

Topic 77

E77.1a –1.46 V

E77.2a Elemental mercury cannot spontaneously displace the zinc(II) cation from solution under standard conditions.

E77.3a (a) 9.2×10^{-9} M (b) 8.3×10^{-17}

E77.4a $-52\ \text{kJ mol}^{-1}$, $-58\ \text{J K}^{-1}\ \text{mol}^{-1}$, $-69\ \text{kJ mol}^{-1}$

E77.5a

	ν	$E_R^\ominus$/V	$E_L^\ominus$/V	$E_{cell}^\ominus$/V	$\Delta_r G_{cell}^\ominus$/(kJ mol^{-1})
(a)	2	+0.80	–0.76	+1.56	–301
(b)	2	0.00	–0.40	+0.40	–77
(c)	3	–0.74	+0.36	–1.10	+318
(d)	2	+0.15	+0.77	–0.62	$+120$

E77.6a (a) –0.13 V, –0.44 V, +0.31 V (b) +0.27 V, 0, +0.27 V (c) +1.23 V, 0, +1.23 V

E77.7a (a) $Cd^{2+}(aq) + 2Br^{-}(aq) + 2\,Ag(s) \rightarrow Cd(s) + 2\,AgBr(s)$ (c) –0.62 V

E77.8a (a) 6.4×10^{9} (b) 8.9×10^{43}

Topic 78

E78.1a (a) 9.975 (b) 1

E78.2a 1904 m s^{-1}, 478 m s^{-1}

E78.3a 0.69 per cent

E78.4a 333 m s^{-1}, 375 m s^{-1}, 530 m s^{-1}

E78.5a (a) 475 m s^{-1} (b) 82.9 nm (c) 8.10×10^{9} s^{-1}

E78.6a 0.195 Pa

E78.7a 1.38×10^{-6} m

E78.8a (a) 5.3×10^{10} s^{-1} (b) 5.3×10^{9} s^{-1} (c) 5.3×10^{3} s^{-1}

E78.9a 1.2×10^{21}

E78.10a 537 s

E78.11a 16 mg

E78.12a $31\overline{9}$ g mol^{-1}

E78.13a 1.3 days

Topic 79

E79.1a 7.6×10^{-3} J K^{-1} m^{-1} s^{-1}

E79.2a (a) $D = 1.5$ m^2 s^{-1}, $J_z/N_A = -61$ mol m^{-2} s^{-1} (b) $D = 1.5\times10^{-5}$ m^2 s^{-1}, $J_z/N_A = -6.1\times10^{-4}$ mol m^{-2} s^{-1} (c) $D = 1.5\times10^{-7}$ m^2 s^{-1}, $J_z/N_A = -6.1\times10^{-6}$ mol m^{-2} s^{-1}

E79.3a –0.078 J m^{-2} s^{-1}

E79.4a 0.0795 nm^2

E79.5a $10\overline{3}$ W

E79.6a 0.201 nm^2

E79.7a (a) $\eta = 178\ \mu P$ (b) $\eta = 186\ \mu P$ (c) $\eta = 342\ \mu P$

Topic 80

E80.1a $16.8\ J\ mol^{-1}$

E80.2a $7.63\times10^{-3}\ S\ m^2\ mol^{-1}$

E80.3a $283\ \mu m\ s^{-1}$

E80.4a $13.87\ mS\ m^2\ mol^{-1}$

E80.5a $4.01\times10^{-8}\ m^2\ V^{-1}\ s^{-1}$, $5.19\times10^{-8}\ m^2\ V^{-1}\ s^{-1}$, $7.62\times10^{-8}\ m^2\ V^{-1}\ s^{-1}$

E80.6a 420 pm

Topic 81

81.1a $6.2\times10^{3}\ s$

81.2a (a) $0.00\ mol\ dm^{-3}$ (b) $0.0121\ mol\ dm^{-3}$

Topic 82

E82.1a No change in pressure

E82.2a 8.1 mol $dm^{-3}\ s^{-1}$, 2.7 mol $dm^{-3}\ s^{-1}$, 2.7 mol $dm^{-3}\ s^{-1}$, 5.4 mol $dm^{-3}\ s^{-1}$

E82.3a $1.3\overline{5}\ mol\ dm^{-3}\ s^{-1}$, $4.0\overline{5}\ mol\ dm^{-3}\ s^{-1}$, 2.7 mol $dm^{-3}\ s^{-1}$, $1.3\overline{5}\ mol\ dm^{-3}\ s^{-1}$

E82.4a $dm^3\ mol^{-1}\ s^{-1}$ (a) $k_r[A][B]$ (b) $3k_r[A][B]$

E82.5a $\frac{1}{2}k_r[A][B][C]$, $dm^6\ mol^{-2}\ s^{-1}$

E82.6a (a) $[k_r] = dm^3\ mol^{-1}\ s^{-1}$, $[k_r] = dm^6\ mol^{-2}\ s^{-1}$ (b) $[k_r] = kPa^{-1}\ s^{-1}$, $[k_r] = kPa^{-2}\ s^{-1}$

Topic 83

E83.1a $n = 2$

E83.2a $1.03\times10^{4}\ s$ (a) 498 Torr (b) 461 Torr

E83.3a (a) $0.098\ mol\ dm^{-3}$ (b) $0.050\ mol\ dm^{-3}$

E83.4a $1.11\times10^{5}\,\text{s} = 1.28\,\text{days}$

Topic 84

E84.1a $4.0\times10^{10}\,\text{dm}^{-3}\,\text{mol}\,\text{s}^{-1}$, $7.1\times10^{5}\,\text{s}^{-1}$, $1.28\times10^{4}\,\text{dm}^{3}\,\text{mol}^{-1}\,\text{s}^{-1}$

Topic 85

E85.1a $1.08\times10^{5}\,\text{J mol}^{-1} = 108\,\text{kJ mol}^{-1}$, $6.50\times10^{15}\,\text{dm}^{3}\,\text{mol}^{-1}\,\text{s}^{-1}$, $6.50\times10^{15}\,\text{dm}^{3}\,\text{mol}^{-1}\,\text{s}^{-1}$

E85.2a $3.49\times10^{4}\,\text{J mol}^{-1} = 34.9\,\text{kJ mol}^{-1}$

Topic 86

E86.1a (i) $k_2K^{1/2}[\text{A}_2]^{1/2}[\text{B}]$ (ii) $\dfrac{k_2{}^2[\text{B}]^2}{4k_1'}\left\{\left(1+\dfrac{16k_1'k_1[\text{A}_2]}{k_2{}^2[\text{B}]^2}\right)^{1/2}-1\right\}$, $k_2K^{1/2}[\text{A}_2]^{1/2}[\text{B}]$, $2k_1[\text{A}_2]$

E86.2a $-3\,\text{kJ mol}^{-1}$

Topic 87

E87.1a $1.13\times10^{10}\,\text{s}^{-1}$, $1.62\times10^{35}\,\text{s}^{-1}\,\text{m}^{-3}$, 1.7 per cent

E87.2a (a) (i) 1.04×10^{-3} (ii) 0.069 (b) (i) 1.19×10^{-15} (ii) 1.57×10^{-6}

E87.3a (a) (i) 22 per cent (ii) 3 per cent (b) (i) 170 per cent (ii) 16 per cent

E87.4a $1.03\times10^{-5}\,\text{m}^{3}\,\text{mol}^{-1}\,\text{s}^{-1} = 1.03\times10^{-2}\,\text{dm}^{3}\,\text{mol}^{-1}\,\text{s}^{-1}$

E87.5a $0.79\,\text{nm}^{2}$, 1.16×10^{-3}

Topic 88

E88.1a $4.\bar{5}\times10^{7}\,\text{m}^{3}\,\text{mol}^{-1}\,\text{s}^{-1} = 4.\bar{5}\times10^{10}\,\text{dm}^{3}\,\text{mol}^{-1}\,\text{s}^{-1}$

E88.2a (a) $6.61\times10^{6}\,\text{m}^{3}\,\text{mol}^{-1}\,\text{s}^{-1} = 6.61\times10^{9}\,\text{dm}^{3}\,\text{mol}^{-1}\,\text{s}^{-1}$ (b) $3.0\times10^{7}\,\text{m}^{3}\,\text{mol}^{-1}\,\text{s}^{-1} = 3.0\times10^{10}\,\text{dm}^{3}\,\text{mol}^{-1}\,\text{s}^{-1}$

E88.3a $8.0\times10^{6}\,\text{m}^{3}\,\text{mol}^{-1}\,\text{s}^{-1} = 8.0\times10^{9}\,\text{dm}^{3}\,\text{mol}^{-1}\,\text{s}^{-1}$, $4.2\times10^{-8}\,\text{s}$

E88.4a $1.81\times10^{8}\ \text{mol dm}^{-3}\ \text{s}^{-1}$

Topic 89

E89.1a $+69.7\ \text{kJ mol}^{-1}$, $-25\ \text{J K}^{-1}\ \text{mol}^{-1}$

E89.2a $+73.4\ \text{kJ mol}^{-1}$, $+71.9\ \text{kJ mol}^{-1}$

E89.3a $-91\ \text{J K}^{-1}\ \text{mol}^{-1}$

E89.4a $-74\ \text{J K}^{-1}\ \text{mol}^{-1}$

E89.5a (a) $-46\ \text{J K}^{-1}\ \text{mol}^{-1}$ (b) $+5.0\ \text{kJ mol}^{-1}$ (c) $+18.7\ \text{kJ mol}^{-1}$

E89.6a $7.1\ \text{dm}^{6}\ \text{mol}^{-2}\ \text{min}^{-1}$

Topic 90

E90.1a Reactant is high in translational energy and low in vibrational energy. Product is high in vibrational energy and relatively lower in translational energy.

Topic 91

E91.1a $1.9\times10^{-6}\ \text{Pa}^{-1}\ \text{s}^{-1}$ or $1.9\ \text{MPa}^{-1}\ \text{s}^{-1}$

E91.2a 0.73

E91.3a 5.1×10^{-7}

Topic 92

E92.1a $\dfrac{k_{\text{b}}K[\text{AH}]^{2}[\text{B}]}{[\text{BH}^{+}]}$

E92.2a $1.50\ \text{mmol dm}^{-3}\ \text{s}^{-1}$

E92.3a $2.0\times10^{-5}\ \text{mol dm}^{-3}$

Topic 93

E93.1a 3.3×10^{18}

E93.2a $0.56\ \text{mol dm}^{-3}$

Topic 94

E94.1a 4×10^{-21} J or $2\ \text{kJ mol}^{-1}$

E94.2a $12.\overline{5}\ \text{nm}^{-1}$

Topic 95

E95.1a (i) $1.4 \times 10^{14}\ \text{cm}^{-2}\ \text{s}^{-1}$ (ii) $3.1 \times 10^{13}\ \text{cm}^{-2}\ \text{s}^{-1}$

E95.2a 0.13 bar

Topic 96

E96.1a $33.6\,\text{cm}^3$

E96.2a Chemisorption, 50 s

E96.3a 0.83, 0.36

E96.4a (a) 0.24 kPa (b) 25 kPa

E96.5a 15 kPa

E96.6a $-12.\overline{4}\ \text{kJ mol}^{-1}$

E96.7a $65\overline{1}\ \text{kJ mol}^{-1}$ (a) 1.6×10^{97} min (b) 2.8×10^{-6} min

E96.8a $61\overline{1}\ \text{kJ mol}^{-1}$

E96.9a (a) 9.1 ps, 0.60 ps (b) 4.1×10^{6} s, 6.6 μs

E96.10a (a) zeroth-order (b) first-order

Topic 97

E97.1a $12\ \text{m}^2$