

Solutions to a) exercises**Foundations****Topic A**

EA.1(a)

	Example	Element	Ground-state Electronic Configuration
(i)	Group 2	Ca, calcium	[Ar]4s ²
(ii)	Group 7	Mn, manganese	[Ar]3d ⁵ 4s ²
(iii)	Group 15	As, arsenic	[Ar]3d ¹⁰ 4s ² 4p ³

EA.2(a) (i) Chemical formula and name: MgCl₂, magnesium chloride
 ions: Mg²⁺ and Cl⁻
 oxidation numbers of the elements: magnesium, +2; chlorine, -1

(ii) Chemical formula and name: FeO, iron(II) oxide
 ions: Fe²⁺ and O²⁻
 oxidation numbers of the elements: iron, +2; oxygen, -2

(iii) Chemical formula and name: Hg₂Cl₂, mercury(I) chloride
 ions: Cl⁻ and Hg₂²⁺ (a polyatomic ion)
 oxidation numbers of the elements: mercury, +1; chlorine, -1

EA.8(a) (i) CO₂ is a linear, nonpolar molecule. (ii) SO₂ is a bent, polar molecule. (iii) N₂O is linear, polar molecule. (iv) SF₄ has a seesaw molecule and it is a polar molecule.

EA.9(a) In the order of increasing dipole moment: CO₂, N₂O, SF₄, SO₂

EA.10(a) (i) Mass is an extensive property. (ii) Mass density is an intensive property. (iii) Temperature is an intensive property. (iv) Number density is an intensive property.

EA.11(a) (i) 0.543 mol (ii) 3.27 × 10²³ molecules

EA.12(a) (i) 180. g (ii) 1.77 N

EA.13(a) 0.43 bar

EA.14(a) 0.42 atm

EA.15(a) 1.47 × 10⁵ Pa

EA.16(a) T = 310.2 K

- EA.17(a) $\theta / ^\circ\text{C} = \frac{5}{9} \times (\theta_{\text{F}} / ^\circ\text{F} - 32)$ or $\theta_{\text{F}} / ^\circ\text{F} = \frac{9}{5} \times \theta / ^\circ\text{C} + 32$, $\theta_{\text{F}} = 173 ^\circ\text{F}$
- EA.18(a) 105 kPa
- EA.19(a) S_8
- EA.20(a) 1.8 MPa
- EA.21(a) $4.6 \times 10^5 \text{ Pa}$, $6.9 \times 10^5 \text{ Pa}$

Topic B

- EB.1(a) (i) 9.81 m s^{-1} , 48 mJ (ii) 29.4 m s^{-1} , 0.43 J
- EB.2(a) $s_{\text{terminal}} = \frac{zeE}{6\pi\eta R}$
- EB.4(a) (i) $2.25 \times 10^{-20} \text{ J}$ (ii) $9.00 \times 10^{-20} \text{ J}$
- EB.5(a) (i) $1.88 \times 10^8 \text{ m s}^{-1}$, 100 keV
- EB.6(a) $1.15 \times 10^{-18} \text{ J}$, $1.48 \times 10^{-20} \text{ J}$
- EB.7(a) -2.40 V
- EB.8(a) 24.1 kJ, 28.8 °C
- EB.9(a) 27.2 K or 27.2 °C
- EB.10(a) 128 J
- EB.11(a) $2.4194 \text{ J K}^{-1} \text{ g}^{-1}$
- EB.12(a) $75.3 \text{ J K}^{-1} \text{ mol}^{-1}$
- EB.13(a) $8.3145 \text{ kJ mol}^{-1}$
- EB.14(a) $S_{\text{H}_2\text{O(g)}} > S_{\text{H}_2\text{O(l)}}$
- EB.15(a) $S_{\text{Fe(3000 K)}} > S_{\text{Fe(300 K)}}$
- EB.17(a) (i) 1.6×10^{-17} (ii) 0.021
- EB.19(a) 4.631×10^{-6}
- EB.21(a) 1.07
- EB.22(a) 1.25

EB.23(a)	0.47 kJ	
EB.24(a)	(i) 1.38 kJ	(ii) 4.56 kJ
EB.25(a)	12.47 J mol ⁻¹ K ⁻¹	
EB.26(a)	(i) 20.79 J mol ⁻¹ K ⁻¹	(ii) 24.94 J mol ⁻¹ K ⁻¹

Topic C

EC.1(a)	2.26 × 10 ⁸ m s ⁻¹
EC.2(a)	4.00 μm, 7.50 × 10 ¹³ Hz

Chapter 1**Topic 1A**

E1A.1(a)	24 atm, no	
E1A.2(a)	(i) 3.42 bar	(ii) 3.38 atm
E1A.3(a)	30 lb in ⁻²	
E1A.4(a)	4.20 × 10 ⁻²	
E1A.5(a)	0.50 m ³	
E1A.6(a)	102 kPa	
E1A.7(a)	8.3147 J K ⁻¹ mol ⁻¹	
E1A.8(a)	S ₈	
E1A.9(a)	6.2 kg	
E1A.10(a)	(i) 0.762, 0.238, 0.752 bar, 0.235 bar	(ii) 0.782, 0.208, 0.0099 bar, 0.772 bar, 0.205 bar
E1A.11(a)	169 g mol ⁻¹	
E1A.12(a)	273°C	
E1A.13(a)	(i) 0.67, 0.33	(ii) 2.0 atm, 1.0 atm (iii) 3.0 atm

Topic 1B

E1B.1(a)	(i) 9.975
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- E1B.2(a) $1.90 \times 10^3 \text{ m s}^{-1} = 1.90 \text{ km s}^{-1}, 458 \text{ m s}^{-1}$
- E1B.3(a) 0.00687
- E1B.4(a) $333 \text{ m s}^{-1}, 375 \text{ m s}^{-1}, 596 \text{ m s}^{-1}$
- E1B.5(a) (i) 475 m s^{-1} (ii) $8.3 \times 10^{-8} \text{ m}$ (iii) $8.1 \times 10^{-9} \text{ s}^{-1}$
- E1B.6(a) $0.19\bar{5} \text{ Pa}$
- E1B.7(a) $1.4 \times 10^{-6} \text{ m}$

Topic 1C

- E1C.1(a) (i) 1.0 atm (ii) $1.8 \times 10^3 \text{ atm}$
- E1C.2(a) $7.61 \times 10^{-2} \text{ kg m}^5 \text{ s}^{-2} \text{ mol}^{-2}, 2.26 \times 10^{-5} \text{ m}^3 \text{ mol}^{-1}$
- E1C.3(a) (i) 0.88 (ii) $1.2 \text{ dm}^3 \text{ mol}^{-1}$, attractive
- E1C.4(a) 140 atm
- E1C.5(a) (i) 50.7 atm (ii) 35.1 atm, 0.692
- E1C.6(a) $1.78 \text{ dm}^6 \text{ atm mol}^{-2}, 0.0362 \text{ dm}^3 \text{ mol}^{-1}, 0.122 \text{ nm}$
- E1C.7(a) (i) $1.41 \times 10^3 \text{ K}$ (ii) 0.139 nm
- E1C.8(a) (i) $3.64 \times 10^3 \text{ K}, 8.7 \text{ atm}$ (ii) $2.62 \times 10^3 \text{ K}, 4.5 \text{ atm}$ (iii) 47K, 0.18 atm
- E1C.9(a) $0.46 \times 10^{-4} \text{ m}^3 \text{ mol}^{-1}, 0.66$

Chapter 2**Topic 2A**

- E2A.1(a) (i) $\frac{7}{2}R, 8.671 \text{ kJ mol}^{-1}$ (ii) $3R, 7.436 \text{ kJ mol}^{-1}$ (iii) $7R, 17.35 \text{ kJ mol}^{-1}$
- E2A.2(a) (i) Pressure, (ii) temperature, and (iv) enthalpy are state functions.
- E2A.3(a) -75 J
- E2A.4(a) (i) $\Delta U = \Delta H = 0, -2.68 \text{ kJ}, +2.68 \text{ kJ}$ (ii) $\Delta U = \Delta H = 0, -1.62 \text{ kJ}, +1.62 \text{ kJ}$ (iii) $\Delta U = \Delta H = 0, w = 0, 0$
- E2A.5(a) 1.33 atm, +1.25 kJ, $w = 0, +1.25 \text{ kJ}$
- E2A.6(a) (i) -88 J (ii) -167 J

Topic 2B

- E2B.1(a) $30 \text{ J K}^{-1} \text{ mol}^{-1}$, $22 \text{ J K}^{-1} \text{ mol}^{-1}$
- E2B.2(a) (i) $1.07 \times 10^4 \text{ J} = +10.7 \text{ kJ}$, $-0.624 \times 10^3 \text{ J} = -0.624 \text{ kJ}$, $+10.1 \text{ kJ}$ (ii) $+10.7 \text{ kJ}$, $+10.1 \text{ kJ}$, $w = 0$, $+10.1 \text{ kJ}$
- E2B.3(a) $+2.2 \text{ kJ}$, $+2.2 \text{ kJ}$, $+1.6 \text{ kJ}$

Topic 2C

- E2C.1(a) 22.5 kJ , -1.6 kJ , 20.9 kJ
- E2C.2(a) $-4564.7 \text{ kJ mol}^{-1}$
- E2C.3(a) $+53 \text{ kJ mol}^{-1}$, -33 kJ mol^{-1}
- E2C.4(a) -167 kJ/mol^{-1}
- E2C.5(a) $-5152 \text{ kJ mol}^{-1}$, 1.58 kJ K^{-1} , $+3.08 \text{ K}$
- E2C.6(a) (i) $-114.40 \text{ kJ mol}^{-1}$, $-111.92 \text{ kJ mol}^{-1}$ (ii) $-92.31 \text{ kJ mol}^{-1}$, $-241.82 \text{ kJ mol}^{-1}$
- E2C.7(a) $-1368 \text{ kJ mol}^{-1}$
- E2C.8(a) (i) $+131.29 \text{ kJ mol}^{-1}$, $+128.81 \text{ kJ mol}^{-1}$ (ii) $+134.14 \text{ kJ mol}^{-1}$, $+130.17 \text{ kJ mol}^{-1}$
- E2C.9(a) $-803.07 \text{ kJ mol}^{-1}$
- E2C.10(a) $-1892 \text{ kJ mol}^{-1}$

Topic 2D

- E2D.1(a) 5.03 mbar
- E2D.2(a) $+130.1 \text{ J mol}^{-1}$, $+7.52 \times 10^3 \text{ J mol}^{-1}$, $-7.39 \times 10^3 \text{ J mol}^{-1}$
- E2D.3(a) $1.31 \times 10^{-3} \text{ K}^{-1}$
- E2D.4(a) $2.0 \times 10^3 \text{ atm}$
- E2D.5(a) $-7.2 \text{ J atm}^{-1} \text{ mol}^{-1}$, $+6.1 \text{ kJ}$

Topic 2E

E2E.1(a)	Closer, closer
E2E.2(a)	$13\bar{1}$ K
E2E.3(a)	$0.0084\bar{6}$ m ³ , $25\bar{7}$ K, -0.89×10^3 J
E2E.4(a)	-194 J
E2E.5(a)	9.7 kPa

Chapter 3**Topic 3A**

E3A.1(a)	Not spontaneous.		
E3A.2(a)	$T_c = 191.2$ K		
E3A.3(a)	(i) 366 J K ⁻¹	(ii) 309 J K ⁻¹	
E3A.4(a)	I ₂ (g)		
E3A.5(a)	3.1 J K ⁻¹		
E3A.6(a)	30.0 kJ/mol ⁻¹		
E3A.7(a)	152.67 J K ⁻¹ mol ⁻¹		
E3A.9(a)	$\Delta H = 0$, $+2.7$ J K ⁻¹ , $\Delta H_{\text{tot}} = 0$		
E3A.10(a)	(i) $+2.9$ J K ⁻¹ , -2.9 J K ⁻¹ , 0	(ii) $+2.9$ J K ⁻¹ , 0 , $+2.9$ J K ⁻¹	(iii) 0 , 0 , 0
E3A.11(a)	(i) $+87.8$ J K ⁻¹ mol ⁻¹	(ii) -87.8 J K ⁻¹ mol ⁻¹	
E3A.12(a)	$\Delta S = 92.2$ J K ⁻¹		

Topic 3B

E3B.1(a)	(i) 9.13 J K ⁻¹ mol ⁻¹	(ii) 13.4 J K ⁻¹ mol ⁻¹	(iii) 14.9 J K ⁻¹ mol ⁻¹
E3B.2(a)	(i) -386.1 J K ⁻¹ mol ⁻¹	(ii) $+92.6$ J K ⁻¹ mol ⁻¹	(iii) -153.1 J K ⁻¹ mol ⁻¹

Topic 3C

E3C.1(a)	(i) $-521.5 \text{ kJ mol}^{-1}$	(ii) $+25.8 \text{ kJ mol}^{-1}$	(iii) $-178.7 \text{ kJ mol}^{-1}$
E3C.2(a)	$-480.98 \text{ kJ mol}^{-1}$		
E3C.3(a)	$817.90 \text{ kJ mol}^{-1}$		
E3C.4(a)	(i) $-522.1 \text{ kJ mol}^{-1}$	(ii) $+25.78 \text{ kJ mol}^{-1}$	(iii) $-178.6 \text{ kJ mol}^{-1}$
E3C.5(a)	-340 kJ mol^{-1}		

Topic 3D

E3D.1(a)	-17 J
E3D.2(a)	-36.5 J K^{-1}
E3D.3(a)	$+10 \text{ kJ}, 1.6 \text{ kJ mol}^{-1}$
E3D.4(a)	$+11 \text{ kJ mol}^{-1}$

Chapter 4**Topic 4A**

E4A.1(a)	(a) Single phase phases	(b) two phases	(c) three phases	(d) two
E4A.2(a)	0.71 J			
E4A.3(a)	4			

Topic 4B

E4B.1(a)	$-1.0 \times 10^{-4} \text{ K}$
E4B.2(a)	$5.2 \times 10^3 \text{ J mol}^{-1} = 5.2 \text{ kJ mol}^{-1}$
E4B.3(a)	70 J mol^{-1}
E4B.4(a)	2.71 kPa
E4B.5(a)	$+45.23 \text{ J K}^{-1} \text{ mol}^{-1}, +16 \text{ kJ mol}^{-1}$
E4B.6(a)	$304 \text{ K}, 31^\circ\text{C}$

E4B.7(a)	+20.80 kJ mol ⁻¹
E4B.8(a)	(i) +34.08 kJ mol ⁻¹ (ii) 350.5 K
E4B.9(a)	281.8 K or 8.7°C
E4B.10(a)	25 g s ⁻¹
E4B.11(a)	(i) 1.7 × 10 ³ g (ii) 31 × 10 ³ g (iii) 1.4 g
E4B.12(a)	(i) +4.9 × 10 ⁴ J mol ⁻¹ = +49 kJ mol ⁻¹ (ii) 215°C, +101 J K ⁻¹ mol ⁻¹
E4B.13(a)	272.80 K
E4B.14(a)	0.0763

Chapter 5

Topic 5A

E5A.1(a)	0, (35.6774 - 0.91846x + 0.051975x ²) cm ³ mol ⁻¹
E5A.2(a)	17.5 cm ³ mol ⁻¹ , 18.07 cm ³ mol ⁻¹
E5A.3(a)	-1.2 J mol ⁻¹
E5A.4(a)	-0.35 kJ, +1.2 J K ⁻¹
E5A.5(a)	+4.70 J K ⁻¹ mol ⁻¹
E5A.6(a)	6.7 kPa
E5A.7(a)	886.8 cm ³
E5A.8(a)	56 cm ³ mol ⁻¹
E5A.9(a)	6.4 × 10 ³ kPa
E5A.10(a)	3.67 × 10 ⁻³ mol dm ⁻³
E5A.11(a)	(i) 3.4 × 10 ⁻³ mol kg ⁻¹ (ii) 3.37 × 10 ⁻² mol kg ⁻¹
E5A.12(a)	0.17 mol dm ⁻³

Topic 5B

E5B.1(a)	1.3 × 10 ² kPa
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- E5B.2(a) 85 g mol^{-1}
- E5B.3(a) $3.8 \times 10^2 \text{ g mol}^{-1}$
- E5B.4(a) -0.09°C
- E5B.5(a) -3.10 kJ , $+10.4 \text{ J K}^{-1}$, 0
- E5B.6(a) (i) $\frac{1}{2}$ (ii) 0.8600
- E5B.7(a) $0.135 \text{ mol kg}^{-1}$, $24.0 \text{ g anthracene}$
- E5B.8(a) 87 kg mol^{-1}
- E5B.9(a) 32.2 Torr , 6.1 Torr , 38.3 Torr , 0.840 , 0.160
- E5B.10(a) 0.92 , 0.08 , 0.97 , 0.03
- E5B.11(a) 0.267 , 0.733 , 58.6 kPa
- E5B.12(a) (i) solution is ideal (ii) 0.830 , 0.1703
- E5B.13(a) (i) 20.6 kPa (ii) 0.668 , 0.332

Topic 5C

- E5C.1(a) (i) $y_M = 0.36$ (ii) $y_M = 0.80$ (*i.e.*, $y_O = 0.20$)
- E5C.4(a) 0.25 , 193°C
- E5C.6(a) (i) 76% (ii) 52% (iii) 1.11 , 1.46
- E5C.7(a) (ii) 620 Torr (iii) 490 Torr (iv) 0.50 , 0.72 (v) 0.50 , 0.30

Chapter 6

Topic 6A

- E6A.1(a) 0.9 mol , 1.2 mol
- E6A.2(a) -0.64 kJ
- E6A.3(a) 5.80×10^5
- E6A.4(a) 2.85×10^{-6}
- E6A.5(a) (i) 0.141 (ii) 13.5
- E6A.6(a) (i) $-68.26 \text{ kJ mol}^{-1}$, 9.13×10^{11} (ii) 1.32×10^9 , $-69.8 \text{ kJ mol}^{-1}$

E6A.7(a) $K = K_c \times (c^\ominus RT / p^\ominus)$

E6A.8(a) (i)

	A	B	C	D	Total
Initial amounts / mol	1.00	2.00	0	1.00	4.00
Stated change / mol			+0.90		
Implied change / mol	-0.60	-0.30	+0.90	+0.60	
Equilibrium amounts / mol	0.40	1.70	0.90	1.60	4.60
Mole fractions	0.087	0.370	0.196	0.348	1.001

(ii) 0.33

(iii) 0.33

(iv) +2.8 kJ mol⁻¹E6A.9(a) +12.3 kJ mol⁻¹E6A.10(a) -14.4 kJ mol⁻¹, toward the ammonia productE6A.11(a) -1108 kJ mol⁻¹**Topic 6B**

E6B.1(a) 0.045, 1500 K

E6B.2(a) +2.77 kJ mol⁻¹, -16.5 J K⁻¹ mol⁻¹

E6B.3(a) 50%

E6B.4(a) 0.9039, 0.0961

E6B.5(a) (i) 52.89 kJ mol⁻¹ (ii) -52.89 kJ mol⁻¹

E6B.6(a) 1110 K

E6B.7(a) 70.2 kJ mol⁻¹, 110 kJ mol⁻¹ K⁻¹, -6.3 kJ mol⁻¹, 3.0**Topic 6C**

E6C.2(a) (i) +1.10 V (ii) +0.22 V (iii) +1.23 V

E6C.3(a) (i) Cd²⁺(aq) + 2Br⁻(aq) + 2 Ag(s) → Cd(s) + 2 AgBr(s) (iii) -0.62 V**Topic 6D**E6D.1(a) (i) 6.5 × 10⁹ (ii) 1.4 × 10¹²E6D.2(a) (i) 8.47 × 10⁻¹⁷ (ii) 9.20 × 10⁻⁹ mol dm⁻³ or 2.16 μg dm⁻³

Chapter 7**Topic 7A**

E7A.1(a) (i) 6.6×10^{-19} J, 4.0×10^2 kJ mol⁻¹ (ii) 6.6×10^{-20} J, 40 kJ mol⁻¹ (iii)
 6.6×10^{-34} J, 4.0×10^{-13} kJ mol⁻¹

E7A.2(a)

λ / nm	E / aJ	E_m / (kJ mol ⁻¹)
(i) 600	331	199
(ii) 550	361	218
(iii) 400	497	299

E7A.3(a)

λ / nm	E_{photon} / aJ	v / (km s ⁻¹)
(i) 600	331	19.9
(ii) 550	361	20.8
(iii) 400	497	24.4

E7A.4(a) 21 m s^{-1}

E7A.5(a) (i) 2.77×10^{18} (ii) 2.77×10^{20}

E7A.6(a) (i) no electron ejection (ii) 3.19×10^{-19} J, 837 km s⁻¹

E7A.7(a) 6.96 keV, 6.96 keV

E7A.8(a) $7.27 \times 10^6 \text{ m s}^{-1}$, 150 V

E7A.9(a) 0.024 m s^{-1}

E7A.10(a) 332 pm

E7A.11(a) (i) 6.6×10^{-29} m (ii) 6.6×10^{-36} m (iii) 99.7 pm

Topic 7B

$$\text{E7B.3(a)} \quad N = \left(\frac{1}{2\pi} \right)^{1/2}$$

$$\text{E7B.4(a)} \quad (1/2\pi) d\phi$$

$$\text{E7B.5(a)} \quad \frac{1}{2}$$

Topic 7C

$$\text{E7C.1(a)} \quad \hat{V} = \frac{1}{2} k_f x^2$$

$$\text{E7C.5(a)} \quad \frac{L}{2}$$

$$\text{E7C.7(a)} \quad 1.1 \times 10^{-28} \text{ ms}^{-1}, 1.1 \times 10^{-27} \text{ m}$$

$$\text{E7C.8(a)} \quad 700 \text{ pm}$$

$$\text{E7C.9(a)} \quad \text{(i) } -\frac{1}{x^2} \quad \text{(ii) } 2x$$

Chapter 8

Topic 8A

$$\text{E8A.1(a)} \quad 5 \times 10^{-20} \text{ J}$$

$$\text{E8A.2(a)} \quad Ae^{ikx}$$

$$\text{E8A.3(a)} \quad \text{(i) } 1.81 \times 10^{-19} \text{ J}, 1.13 \text{ eV}, 9100 \text{ cm}^{-1}, 109 \text{ kJ mol}^{-1} \quad \text{(ii) } 6.6 \times 10^{-19} \text{ J}, 4.1 \text{ eV}, 33\,000 \text{ cm}^{-1}, 400 \text{ kJ mol}^{-1}$$

$$\text{E8A.4(a)} \quad \text{(i) } 0.04 \quad \text{(ii) } 0$$

$$\text{E8A.5(a)} \quad \frac{h^2}{4L^2}$$

$$\text{E8A.6(a)} \quad L^2 \left(\frac{1}{3} - \frac{1}{2\pi^2} \right)$$

$$\text{E8A.7(a)} \quad \frac{h}{8^{1/2} m_e c} = \frac{\lambda_c}{8^{1/2}}$$

$$\text{E8A.8(a)} \quad \frac{L}{6}, \frac{L}{2} \text{ and } \frac{5L}{6}$$

E8A.9(a)	-17.4%
E8A.10(a)	$\frac{2kTmL^2}{h^2} - \frac{1}{2}$
E8A.11(a)	$n_1=1, n_2=4$
E8A.12(a)	3
E8A.13(a)	0.8

Topic 8B

E8B.1(a)	4.30×10^{-21} J
E8B.2(a)	278 N m ⁻¹
E8B.3(a)	2.64 μm
E8B.4(a)	8.3673×10^{-28} kg, 1.6722×10^{-27} kg, 93.3 THz
E8B.5(a)	(i) 3.3×10^{-34} J (ii) 3.3×10^{-33} J
E8B.6(a)	5.61×10^{-21} J
E8B.7(a)	$\pm 0.525\alpha$ or $\pm 1.65\alpha$
E8B.8(a)	$\pm\alpha$
E8B.9(a)	0.056, 0.112

Topic 8C

E8C.1(a)	$0, \pm\hbar$
E8C.2(a)	$\left(\frac{1}{2\pi}\right)^{1/2}$
E8C.3(a)	3.32×10^{-22} J
E8C.4(a)	2.11×10^{-22} J
E8C.5(a)	4.22×10^{-22} J
E8C.6(a)	$2^{1/2}\hbar, 1.49 \times 10^{-34}$ J s
E8C.8(a)	7

Chapter 9**Topic 9A**

E9A.1(a) (i) $g = 1$ (ii) $g = 9$ (iii) $g = 25$

E9A.2(a) $N = \frac{2}{a_0^{3/2}}$

E9A.3(a) $4a_0, r = 0.$

E9A.4(a) $r = 0.35a_0$

E9A.5(a) 101 pm and 376 pm

E9A.6(a) $2E_{1s}, -E_{1s}$

E9A.7(a) $5.24 \frac{a_0}{Z}$

E9A.8(a) $r = 2a_0 / Z$

E9A.10(a) $6a_0 / Z$, xy plane, $\theta = \pi/2$, yz , $\theta = 0$, xz , $\theta = 0$

Topic 9B

E9B.2(a) (i) $[\text{Ar}]3d^8$ (ii) $S = 1, 0, M_S = -1, 0, +1, M_S = 0$

Topic 9C

E9C.1(a) $9.118 \times 10^{-6} \text{ cm}, 1.216 \times 10^{-5} \text{ cm}$

E9C.2(a) $3.292 \times 10^5 \text{ cm}^{-1}, 3.038 \times 10^{-6} \text{ cm}, 9.869 \times 10^{15} \text{ s}^{-1}$

E9C.3(a) 14.0 eV

E9C.4(a) (i) Forbidden (ii) allowed (iii) allowed

E9C.5(a) (i) $\frac{5}{2}, \frac{3}{2}$ (ii) $\frac{7}{2}, \frac{5}{2}$

E9C.6(a) $l = 1$

E9C.7(a) $L = 2, S = 0, J = 2$

E9C.8(a) (i) 1, 0, 3, 1 (ii) $\frac{3}{2}, \frac{1}{2}$, and $\frac{1}{2}, 4, 2, 2$

- E9C.9(a) ${}^3D_3, {}^3D_2, {}^3D_1, {}^1D_2, {}^3D$ set of terms are the lower in energy
- E9C.10(a) (i) $J = 0$, 1 state (ii) $J = \frac{3}{2}, \frac{1}{2}$, 4, 2 states respectively (iii) $J = 2, 1, 0$, 5, 3, 1 states respectively
- E9C.11(a) (i) ${}^2S_{1/2}$ (ii) ${}^2P_{3/2}$ and ${}^2P_{1/2}$
- E9C.12(a) (i) Allowed (ii) forbidden (iii) allowed

Chapter 10

Topic 10A

- E10A.1(a) $\{s(1)p_z(2) + s(2)p_z(1)\} \times \{\alpha(1)\beta(2) - \alpha(2)\beta(1)\}$
- E10A.2(a) $\psi = a\psi_{\text{VB}} + b\psi_{\text{H}^+\text{F}^-} + c\psi_{\text{H}^+\text{F}^-}$
- E10A.6(a) $N = 3^{-1/2}$, $\psi = 3^{-1/2}(s + 2^{1/2}p)$

Topic 10B

- E10B.1(a) $N = \left(\frac{1}{1 + 2\lambda S + \lambda^2} \right)^{1/2}$
- E10B.2(a) $N = 1.12$, $\psi_1 = 0.163A + 0.947B$, $b = 0.412$, $a = -1.02$, $\psi_2 = -1.02A + 0.412B$
- E10B.3(a) 1.9 eV, 130 pm
- E10B.4(a) u, g

Topic 10C

- E10C.1(a) (i) $1\sigma_g^2, b=1$ (ii) $1\sigma_g^2 1\sigma_u^2, b=0$ (iii) $1\sigma_g^2 1\sigma_u^2 1\pi_u^4, b=2$
- E10C.2(a) C_2
- E10C.3(a) F_2^+
- E10C.4(a) $b=1, b=0, b=1, b=2, b=3, b=2, b=1$
- E10C.5(a) $1\sigma_g, 1\sigma_u, 1\pi_u, 1\pi_u, 2\sigma_g, 1\pi_g, 1\pi_g, 1\sigma_u, 1\pi_u, 1\pi_u, 2\sigma_g, 1\pi_g, 1\pi_g, 2\sigma_u$
- E10C.6(a) $4 \times 10^5 \text{ m s}^{-1}$
- E10C.7(a) (i) $2.1 \times 10^{-10} \text{ m} = 0.21 \text{ nm}$ (ii) $1.0 \times 10^{-10} \text{ m} = 0.10 \text{ nm}$

Topic 10D

- E10D.1(a) (i) $1\sigma^2 2\sigma^2 1\pi^4 3\sigma^2$ (ii) $1\sigma^2 2\sigma^2 3\sigma^2 1\pi^4 2\pi^1$ (iii) $1\sigma^2 2\sigma^2 1\pi^4 3\sigma^2$
- E10D.3(a) NO^+
- E10D.5(a) 7.2, 8.3
- E10D.6(a) -6.6 or -8.9
- E10D.7(a) -5.0 or -10.7 eV

Topic 10E

- E10E.2(a) (i) $a_{2u}^2 e_{1g}^4 e_{2u}^1$, $7\alpha + 7\beta$ (ii) $a_{2u}^2 e_{1g}^3$, $5\alpha + 7\beta$
- E10E.3(a) (i) $7\beta, 0$ (ii) $7\beta, 2\beta$
- E10E.5(a) (i) $14\alpha + 19.314\beta$ (ii) $14\alpha + 19.448\beta$

Chapter 11**Topic 11A**

- E11A.1(a) Identity E , C_3 axis, three vertical mirror planes σ_v
- E11A.2(a) D_{2h} , $3C_2$ axes, a centre of inversion, $3\sigma_h$ mirror planes
- E11A.3(a) (i) R_3 (ii) C_{2v} (iii) D_{3h} (iv) $D_{\infty h}$
- E11A.4(a) (i) C_{2v} (ii) $C_{\infty v}$ (iii) C_{3v} (iv) D_{2h}
- E11A.5(a) (i) C_{2v} (ii) C_{2h}
- E11A.6(a) (i) pyridine (ii) nitroethane
- E11A.7(a)

Isomers and Point Groups of m,n -Dichloronaphthalene										
m,n	1,2	1,3	1,4	1,5	1,6	1,7	1,8	2,3	2,6	2,7
Point Group	C_s	C_s	C_{2v}	C_{2h}	C_s	C_s	C_{2v}	C_{2v}	C_{2h}	C_{2v}

E11A.8(a) i, σ_h **Topic 11B**

$$E11B.1(a) \quad D(\sigma_h) = \begin{pmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}$$

$$E11B.2(a) \quad \begin{pmatrix} -1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \\ 0 & -1 & 0 & 0 \end{pmatrix} = D(S_3)$$

Topic 11CE11C.4(a) no N orbitals, d_{xy} E11C.6(a) $2A_1 + B_1 + E$ E11C.7(a) (i) Either E_{1u} or A_{2u} (ii) B_{3u} (x -polarized), B_{2u} (y -polarized), B_{1u} (z -polarized)

E11C.8(a) zero

Chapter 12**Topic 12A**E12A.1(a) (i) $0.0469 \text{ J m}^{-3} \text{ s}$ (ii) $1.33 \times 10^{-13} \text{ J m}^{-3} \text{ s}$ (iii) $4.50 \times 10^{-28} \text{ J m}^{-3} \text{ s}$

E12A.2(a) 82.9 %

E12A.3(a) $5.34 \times 10^3 \text{ dm}^3 \text{ mol}^{-1} \text{ cm}^{-1}$ E12A.4(a) $1.09 \text{ mmol dm}^{-3}$

- E12A.5(a) $450 \text{ dm}^3 \text{ mol}^{-1} \text{ cm}^{-2}$
- E12A.6(a) $159 \text{ dm}^3 \text{ mol}^{-1} \text{ cm}^{-1}$, 23 per cent
- E12A.7(a) (i) 0.87 m (ii) 2.9 m
- E12A.8(a) $1.3 \times 10^8 \text{ dm}^3 \text{ mol}^{-1} \text{ cm}^{-2}$
- E12A.9(a) (i) $5 \times 10^7 \text{ dm}^3 \text{ mol}^{-1} \text{ cm}^{-2}$ (ii) $2.5 \times 10^6 \text{ dm}^3 \text{ mol}^{-1} \text{ cm}^{-2}$
- E12A.10(a) $0.9999 \times \lambda$
- E12A.11(a) (i) 27 ps (ii) 2.7 ps
- E12A.12(a) (i) $\delta \tilde{\nu} = 53 \text{ cm}^{-1}$ (ii) $\delta \tilde{\nu} = 0.53 \text{ cm}^{-1}$

Topic 12B

- E12B.1(a) $6.33 \times 10^{-46} \text{ kg m}^2$, 0.4421 cm^{-1}
- E12B.3(a) (i) Asymmetric (ii) oblate symmetric (iii) spherical (iv) prolate symmetric
- E12B.4(a) 106.5 pm, 115.6 pm
- E12B.5(a) $2.073 \times 10^{-4} \text{ cm}^{-1}$, 0.1253

Topic 12C

- E12C.2(a) $3.07 \times 10^{11} \text{ Hz}$
- E12C.3(a) 127.4 pm
- E12C.4(a) $4.442 \times 10^{-47} \text{ kg m}^2$, 165.9 pm
- E12C.5(a) (i) 20 (ii) 23
- E12C.6(a) (iii) CH_4 is inactive, (i), (ii), and (iv) are active.
- E12C.7(a) $20\,475 \text{ cm}^{-1}$
- E12C.8(a) 198.9 pm
- E12C.9(a) $\frac{5}{3}$

Topic 12D

E12D.1(a)	$1.6 \times 10^2 \text{ N m}^{-1}$
E12D.2(a)	1.077 %
E12D.3(a)	328.7 N m^{-1}
E12D.4(a)	967.0, 515.6, 411.8, 314.2
E12D.5(a)	(i) 0.067 (ii) 0.20
E12D.6(a)	1580.38 cm^{-1} , 7.644×10^{-3}
E12D.7(a)	5.13 eV

Topic 12E

E12E.3(a)	127
E12E.4(a)	$\frac{1}{2}(\tilde{\nu}_1 + \tilde{\nu}_2 + \tilde{\nu}_3)$
E12E.6(a)	Raman active
E12E.7(a)	$4A_1 + A_2 + 2B_1 + 2B_2$
E12E.8(a)	A_1, B_1 and B_2 are infrared active, all modes are Raman active

Chapter 13

Topic 13A

E13A.1(a)	3, u
E13A.2(a)	(i) Allowed (ii) allowed (iii) forbidden (iv) forbidden (v) allowed
E13A.3(a)	$\frac{2\sqrt{2}}{3} e^{-2a\tilde{\nu}_0^2/3}$
E13A.4(a)	$\frac{1}{32} \left(3 + \frac{4}{\pi} \right)^2$
E13A.5(a)	$\frac{1}{2}(\tilde{B}' + \tilde{B}) / (\tilde{B}' - \tilde{B})$
E13A.6(a)	$\frac{1}{2}(\tilde{B}' + \tilde{B}) / (\tilde{B}' - \tilde{B}) - 1, 7$
E13A.7(a)	$30.4 \text{ cm}^{-1} < \tilde{B}' < 40.5 \text{ cm}^{-1}$, greater
E13A.8(a)	$\Delta_0 = P - \tilde{\nu}$, $14 \times 10^3 \text{ cm}^{-1}$

$$\text{E13A.9(a)} \quad \frac{3}{8} \left(\frac{a^3}{b - \frac{1}{2}a} \right)^{1/2}$$

$$\text{E13A.10(a)} \quad \frac{1}{4} e^{-1/16} a$$

Topic 13B

13B.1(a) (i) Lower, $\tilde{\nu} \approx 1800 \text{ cm}^{-1}$ (ii) no information

Topic 13C

E13C.1(a) $\lambda = 2.0 \text{ cm}$ ($\nu = 15.0 \text{ GHz}$)

E13C.2(a) 20 ps, 70 MHz

Chapter 14**Topic 14A**

E14A.1(a) $\text{s}^{-1} \text{ T}^{-1}$

E14A.2(a) $9.133 \times 10^{-35} \text{ J s}$, $\pm 5.273 \times 10^{-35} \text{ J s}$, $\pm 0.9553 \text{ rad} = \pm 54.74^\circ$

E14A.3(a) 574 MHz

E14A.4(a) $-1.473 \times 10^{-26} \text{ J} \times m_l$

E14A.5(a) 165 MHz

E14A.6(a) (i) $3.98 \times 10^{-25} \text{ J}$ (ii) $6.11 \times 10^{-26} \text{ J}$, (a).

E14A.7(a) (i) 1×10^{-6} (ii) 5.1×10^{-6} (iii) 3.4×10^{-5}

E14A.8(a) 13

E14A.9(a) $2 \times 10^2 \text{ T}$, 10 mT

Topic 14B

E14B.1(a) (i) Independent (ii) 13

E14B.2(a) (i) $11\mu\text{T}$ (ii) $110\mu\text{T}$

E14B.5(a) 753 MHz

E14B.9(a) 0.39 ms, $2.6 \times 10^3 \text{s}^{-1}$

Topic 14C

E14C.1(a) $9.40 \times 10^{-4} \text{T}$, 6.25 μs

E14C.2(a) 0.21 s

E14C.3(a) 1.234

Topic 14D

E14D.1(a) 2.0022

E14D.2(a) 2.3 mT, $2.002\bar{5}$

E14D.3(a) Equal intensity, 330.2 mT, 332.2 mT, 332.8 mT, 334.8 mT

E14D.5(a) (i) 332.3 mT (ii) 1.206 T

E14D.6(a) $I = \frac{3}{2}$

Chapter 15

Topic 15A

E15A.1(a) 21621600

E15A.2(a) (i) 40320 (ii) 5.63×10^3 (iii) 3.99×10^4

E15A.3(a) 1

E15A.4(a) 524 K

E15A.5(a) 7.43

E15A.6(a) $35\bar{4}$ K

Topic 15B

E15B.1(a)	(i) 8.23×10^{-12} m, 8.23 pm, 2.60×10^{-12} m, 2.60 pm	(ii) 1.79×10^{27} , 5.67×10^{28}
E15B.2(a)	0.3574	
E15B.3(a)	72.2	
E15B.4(a)	(i) 7.97×10^3	(ii) 1.12×10^4
E15B.5(a)	18 K	
E15B.6(a)	37 K	
E15B.7(a)	4.5 K	
E15B.8(a)	(i) 1	(ii) 2 (iii) 2 (iv) 12 (v) 3
E15B.9(a)	660.6	
E15B.10(a)	4500 K	
E15B.11(a)	2.571	
E15B.12(a)	42.3	
E15B.13(a)	4.292, 0.0353 to 0.0377 to 1	

Topic 15C

E15C.1(a)	8.16×10^{-22} J
E15C.2(a)	18.5 K
E15C.3(a)	25 K
E15C.4(a)	4.5 K
E15C.5(a)	4600 K
E15C.6(a)	10500 K
E15C.7(a)	6500 K
E15C.8(a)	4.033×10^{-21} J

Topic 15D

E15D.1(a)	He gas, CO gas, H ₂ O vapour
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Topic 15E

- E15E.1(a) (i) $\frac{7}{2}R$ (ii) $3R$ (iii) $7R$
- E15E.2(a) Closer, closer
- E15E.3(a) (i) 4.158 (ii) 4.489
- E15E.4(a) (i) $14.93 \text{ J K}^{-1} \text{ mol}^{-1}$ (ii) $25.65 \text{ J K}^{-1} \text{ mol}^{-1}$
- E15E.5(a) (i) $126 \text{ J K}^{-1} \text{ mol}^{-1}$ (ii) $169 \text{ J K}^{-1} \text{ mol}^{-1}$
- E15E.6(a) $2.35 \times 10^3 \text{ K}$
- E15E.7(a) 43.1, 22.36 K, $43.76 \text{ J K}^{-1} \text{ mol}^{-1}$
- E15E.8(a) $11.5 \text{ J K}^{-1} \text{ mol}^{-1}$
- E15E.9(a) (i) $34.72 \text{ J K}^{-1} \text{ mol}^{-1}$ (ii) $119.06 \text{ J K}^{-1} \text{ mol}^{-1}$

Topic 15F

- E15F.1(a) $-13.8 \text{ kJ mol}^{-1}$, $-0.20 \text{ kJ mol}^{-1}$
- E15F.2(a) (i) $-6.42 \text{ kJ mol}^{-1}$ (ii) $-14.0 \text{ kJ mol}^{-1}$
- E15F.3(a) 3.70×10^{-3}

Chapter 16**Topic 16A**

- E16A.1(a) ClF_3 , O_3 , H_2O_2
- E16A.2(a) 1.4 D
- E16A.3(a) 37 D, $11.\bar{7}^\circ$
- E16A.4(a) 1.66 D, $1.01 \times 10^{-39} \text{ J}^{-1} \text{ C}^2 \text{ m}^2$, $9.06 \times 10^{-30} \text{ m}^3$
- E16A.5(a) 4.75
- E16A.6(a) $1.42 \times 10^{-39} \text{ J}^{-1} \text{ C}^2 \text{ m}^2$
- E16A.7(a) 1.34
- E16A.8(a) 17.7

Topic 16B

E16B.1(a) $1.07 \times 10^3 \text{ kJ mol}^{-1}$

E16B.2(a) $\frac{6l^4 Q_1^2}{\pi \epsilon_0 r^5}$

E16B.3(a) 0.071 J mol^{-1}

E16B.4(a) 289 kJ mol^{-1}

Topic 16C

E16C.1(a) 2.6 kPa

E16C.2(a) 72.8 mN m^{-1}

E16C.3(a) 728 kPa

Chapter 17**Topic 17A**

E17A.1(a) 27 nm

E17A.2(a) $3.08 \text{ } \mu\text{m}, 30.8 \text{ nm}$

E17A.3(a) 2.4×10^3

E17A.4(a) 0.017

E17A.5(a) 6.4×10^{-3}

E17A.6(a) $+41.42\%, +182.8\%$

E17A.7(a) $+895\% \text{ when } N = 1000, +9.84 \times 10^4\% \text{ when } N = 1000$

E17A.8(a) $1.6 \times 10^2 \text{ pm}$

Topic 17B

E17B.1(a) $-19 \text{ mJ mol}^{-1} \text{ K}^{-1}$

E17B.2(a) $3.7 \times 10^{-14} \text{ N}$

Topic 17C

E17C.1(a) 3.43

Topic 17DE17D.1(a) 70 kg mol^{-1} , 71 kg mol^{-1} E17D.2(a) (i) 18 kg mol^{-1} (ii) 20 kg mol^{-1}

E17D.3(a) 100

E17D.4(a) 64 kg mol^{-1} E17D.5(a) 0.73 mm s^{-1} E17D.6(a) 31 kg mol^{-1} E17D.7(a) $3.4 \times 10^3 \text{ kg mol}^{-1}$ **Chapter 18****Topic 18A**E18A.1(a) $N = 4$, 4.01 g cm^{-3}

E18A.2(a) (323) and (110)

E18A.3(a) 229 pm , 397 pm , 115 pm E18A.4(a) 220 pm E18A.5(a) 70.7 pm E18A.6(a) 10.1° , 14.4° , 17.7° E18A.7(a) 8.16° , 4.82° , $11.7\bar{5}^\circ$ E18A.8(a) $f_{\text{Br}^-} = 36$ E18A.9(a) $f_{\text{Br}^-} = 36$ E18A.10(a) f E18A.11(a) $3f$ for $h+k$ even and $-f$ for $h+k$ oddE18A.15(a) 6.1 km s^{-1}

E18A.16(a) 233 pm

Topic 18B

E18B.1(a) 0.9069

E18B.2(a) (i) 0.5236 (ii) 0.6802 (iii) 0.7405

E18B.3(a) (i) 74.9 pm (ii) 132 pm

E18B.4(a) Expansion

E18B.5(a) 3500. kJ mol⁻¹**Topic 18C**E18C.1(a) $9.3 \times 10^{-4} \text{ cm}^3$

E18C.2(a) n-type; the dopant, arsenic, belongs to Group 15 whereas germanium belongs to Group 14.

E18C.3(a) Three unpaired spins

E18C.4(a) $-6.4 \times 10^{-5} \text{ cm}^3 \text{ mol}^{-1} = -6.4 \times 10^{-11} \text{ m}^3 \text{ mol}^{-1}$

E18C.5(a) 4.326, 5

E18C.6(a) $+1.6 \times 10^{-8} \text{ m}^3 \text{ mol}^{-1}$ **Topic 18D**

E18D.1(a) 3.54 eV

Chapter 19**Topic 19A**E19A.1(a) $7.6 \times 10^{-3} \text{ J K}^{-1} \text{ m}^{-1} \text{ s}^{-1}$ E19A.2(a) (i) $D = 1.5 \text{ m}^2 \text{ s}^{-1}$, $J_z/N_A = -61 \text{ mol m}^{-2} \text{ s}^{-1}$ (ii) $D = 1.5 \times 10^{-5} \text{ m}^2 \text{ s}^{-1}$, $J_z/N_A = -6.1 \times 10^{-4} \text{ mol m}^{-2} \text{ s}^{-1}$ (iii) $D = 1.5 \times 10^{-7} \text{ m}^2 \text{ s}^{-1}$, $J_z/N_A = -6.1 \times 10^{-6} \text{ mol m}^{-2} \text{ s}^{-1}$ E19A.3(a) $-0.078 \text{ J m}^{-2} \text{ s}^{-1}$

E19A.4(a)	0.0795 nm^2
E19A.5(a)	$10\bar{3} \text{ W}$
E19A.6(a)	0.201 nm^2
E19A.7(a)	(i) $\eta = 178 \text{ }\mu\text{P}$ (ii) $\eta = 186 \text{ }\mu\text{P}$ (iii) $\eta = 342 \text{ }\mu\text{P}$
E19A.8(a)	1.9×10^{20}
E19A.9(a)	104 mg
E19A.10(a)	$2.15 \times 10^3 \text{ Pa}$
E19A.11(a)	42.4 g mol^{-1}
E19A.12(a)	1.3 days

Topic 19B

E19B.1(a)	16.8 J mol^{-1}
E19B.2(a)	$7.63 \times 10^{-3} \text{ S m}^2 \text{ mol}^{-1}$
E19B.3(a)	$283 \text{ }\mu\text{m s}^{-1}$
E19B.4(a)	$13.87 \text{ mS m}^2 \text{ mol}^{-1}$
E19B.5(a)	$4.01 \times 10^{-8} \text{ m}^2 \text{ V}^{-1} \text{ s}^{-1}$, $5.19 \times 10^{-8} \text{ m}^2 \text{ V}^{-1} \text{ s}^{-1}$, $7.62 \times 10^{-8} \text{ m}^2 \text{ V}^{-1} \text{ s}^{-1}$
E19B.6(a)	420 pm
E19B.7(a)	$1.90 \times 10^{-9} \text{ m}^2 \text{ s}^{-1}$

Topic 19C

E19C.1(a)	$6.2 \times 10^3 \text{ s}$
E19C.2(a)	(i) 0.00 mol dm^{-3} (ii) $0.0121 \text{ mol dm}^{-3}$
E19C.3(a)	25 kN mol^{-1} , ∞
E19C.4(a)	67.5 kN mol^{-1}
E19C.5(a)	$1.3 \times 10^3 \text{ s}$
E19C.6(a)	0.42 nm

- E19C.7(a) 27.3 ps
 E19C.8(a) 113 μm , 56 μm

Chapter 20

Topic 20A

- E20A.1(a) No change in pressure
 E20A.2(a) 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
 E20A.3(a) 1.35 mol dm⁻³ s⁻¹, 4.05 mol dm⁻³ s⁻¹, 2.7 mol dm⁻³ s⁻¹, 1.35 mol dm⁻³ s⁻¹
 E20A.4(a) dm³ mol⁻¹ s⁻¹, (i) $k_r[A][B]$ (ii) $3k_r[A][B]$
 E20A.5(a) $\frac{1}{2}k_r[A][B][C]$, dm⁶ mol⁻² s⁻¹
 E20A.6(a) (i) $[k_r] = \text{dm}^3 \text{mol}^{-1} \text{s}^{-1}$, $[k_r] = \text{dm}^6 \text{mol}^{-2} \text{s}^{-1}$ (ii) $[k_r] = \text{kPa}^{-1} \text{s}^{-1}$, $[k_r] = \text{kPa}^{-2} \text{s}^{-1}$

Topic 20B

- E20B.1(a) $n = 2$
 E20B.2(a) 1.03 × 10⁴ s, (i) 498 Torr (ii) 461 Torr
 E20B.3(a) (i) 0.098 mol dm⁻³ (ii) 0.050 mol dm⁻³
 E20B.4(a) 1.11 × 10⁵ s, 1.28 days

Topic 20C

- E20C.1(a) 7.1 × 10⁵ s⁻¹, 1.28 × 10⁴ dm³ mol⁻¹ s⁻¹

Topic 20D

- E20D.1(a) 1.08 × 10⁵ J mol⁻¹ = 108 kJ mol⁻¹, 6.50 × 10¹⁵ dm³ mol⁻¹ s⁻¹, 6.50 × 10¹⁵ dm³ mol⁻¹ s⁻¹
 E20D.2(a) 35 kJ mol⁻¹

Topic 20E

$$\text{E20E.1(a)} \quad (\text{i}) \quad k_2 K^{1/2} [\text{A}_2]^{1/2} [\text{B}] \quad (\text{ii}) \quad \frac{k_2^2 [\text{B}]^2}{4k_1'} \left(\sqrt{1 + \frac{16k_1' k_1 [\text{A}_2]}{k_2^2 [\text{B}]^2}} - 1 \right), \quad k_2 K^{1/2} [\text{A}_2]^{1/2} [\text{B}], \quad 2k_1 [\text{A}_2]$$

$$\text{E20E.2(a)} \quad -3 \text{ kJ mol}^{-1}$$

Topic 20F

$$\text{E20F.1(a)} \quad 1.9 \times 10^{-6} \text{ Pa}^{-1} \text{ s}^{-1}, \quad 1.9 \text{ MPa}^{-1} \text{ s}^{-1}$$

$$\text{E20F.2(a)} \quad 251, \quad 0.996$$

$$\text{E20F.3(a)} \quad 0.125$$

Topic 20G

$$\text{E20G.1(a)} \quad 3.3 \times 10^{18}$$

$$\text{E20G.2(a)} \quad 0.56 \text{ mol dm}^{-3}$$

Topic 20H

$$\text{E20H.1(a)} \quad \frac{k_b K [\text{AH}]^2 [\text{B}]}{[\text{BH}^+]}$$

$$\text{E20H.2(a)} \quad 1.50 \text{ mmol dm}^{-3} \text{ s}^{-1}$$

$$\text{E20H.3(a)} \quad 2.0 \times 10^{-5} \text{ mol dm}^{-3}$$

Chapter 21**Topic 21A**

$$\text{E21A.1(a)} \quad 1.13 \times 10^{10} \text{ s}^{-1}, \quad 1.62 \times 10^{35} \text{ s}^{-1} \text{ m}^{-3}, \quad 1.7\%$$

$$\text{E21A.2(a)} \quad (\text{i}) \quad 1.04 \times 10^{-3}, \quad 0.069 \quad (\text{ii}) \quad 1.19 \times 10^{-15}, \quad 1.57 \times 10^{-6}$$

$$\text{E21A.3(a)} \quad (\text{i}) \quad 22\%, \quad 3\% \quad (\text{ii}) \quad 170\%, \quad 16\%$$

$$\text{E21A.4(a)} \quad 1.03 \times 10^{-5} \text{ m}^3 \text{ mol}^{-1} \text{ s}^{-1}, \quad 1.03 \times 10^{-2} \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$$

E21A.5(a) $0.79 \text{ nm}^2, 1.16 \times 10^{-3}$

E21A.6(a) 0.73

E21A.7(a) 5.1×10^{-7}

Topic 21B

E21B.1(a) $4.5 \times 10^7 \text{ m}^3 \text{ mol}^{-1} \text{ s}^{-1}, 4.5 \times 10^{10} \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$

E21B.2(a) (i) $6.61 \times 10^6 \text{ m}^3 \text{ mol}^{-1} \text{ s}^{-1}, 6.61 \times 10^9 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$ (ii) $3.0 \times 10^7 \text{ m}^3 \text{ mol}^{-1} \text{ s}^{-1}, 3.0 \times 10^{10} \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$

E21B.3(a) $8.0 \times 10^6 \text{ m}^3 \text{ mol}^{-1} \text{ s}^{-1}, 8.0 \times 10^9 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}, 4.2 \times 10^{-8} \text{ s}$

E21B.4(a) $1.81 \times 10^8 \text{ mol dm}^{-3} \text{ s}^{-1}$

Topic 21C

E21C.1(a) $+69.7 \text{ kJ mol}^{-1}, -25 \text{ J K}^{-1} \text{ mol}^{-1}$

E21C.2(a) $+73.4 \text{ kJ mol}^{-1}, +71.9 \text{ kJ mol}^{-1}$

E21C.3(a) $-91 \text{ J K}^{-1} \text{ mol}^{-1}$

E21C.4(a) $-74 \text{ J K}^{-1} \text{ mol}^{-1}$

E21C.5(a) (i) $-46 \text{ J K}^{-1} \text{ mol}^{-1}$ (ii) $+5.0 \text{ kJ mol}^{-1}$ (iii) $+18.7 \text{ kJ mol}^{-1}$

E21C.6(a) $7.1 \text{ dm}^6 \text{ mol}^{-2} \text{ min}^{-1}$

Topic 21D

E21D.1(a) Reactant is high in translational energy and low in vibrational energy, product is high in vibrational energy and relatively lower in translational energy

Topic 21E

E21E.1(a) $4 \times 10^{-21} \text{ J}, 2 \text{ kJ mol}^{-1}$

E21E.2(a) 12.5 nm^{-1}

Topic 21F

E21F.1(a)	0.138 V
E21F.2(a)	2.82 mA cm ⁻²
E21F.3(a)	Increases, factor of 50
E21F.4(a)	(i) 1.7×10^{-4} A cm ⁻² (ii) 1.7×10^{-4} A cm ⁻²
E21F.5(a)	(i) 0.31 mA cm ⁻² (ii) 5.44 mA cm ⁻² (iii) -2×10^{42} mA cm ⁻²
E21F.6(a)	4.9×10^{15} cm ⁻² s ⁻¹ , 1.6×10^{16} cm ⁻² s ⁻¹ , 3.1×10^7 cm ⁻² s ⁻¹ , 3.9 s ⁻¹ , 12 s ⁻¹ , 2.4×10^{-8} s ⁻¹
E21F.7(a)	(i) 33 Ω (ii) 3.3×10^{10} Ω
E21F.8(a)	One can (barely) deposit zinc

Chapter 22**Topic 22A**

22A.1(a)	(i) 1.4×10^{14} cm ⁻² s ⁻¹ (ii) 3.1×10^{13} cm ⁻² s ⁻¹
22A.2(a)	0.13 bar

Topic 22B

E22B.1(a)	33.6 cm ³
E22B.2(a)	Chemisorption, 50 s
E22B.3(a)	0.83, 0.36
E22B.4(a)	(i) 0.24 kPa (ii) 25 kPa
E22B.5(a)	15 kPa
E22B.6(a)	-12.4 kJ mol ⁻¹
E22B.7(a)	65 kJ mol ⁻¹ (i) 1.6×10^{97} min (ii) 2.8×10^{-6} min
E22B.8(a)	61 kJ mol ⁻¹
E22B.9(a)	(i) 9.1 ps, 0.60 ps (ii) 4.1×10^6 s, 6.6 μs
E22B.10(a)	Zeroth-order, first-order

Topic 22C

E22C.1(a) 12 m²