PHY332: Numerical answers to past exam papers

Autumn Semester 2016-17

Question	Answer
1(a)	351 eV
1(b)	-3.181 eV
1(c)	18
1(d)	$^2D_{3/2} \rightarrow {}^2S_{1/2}$ ($\Delta L=2$) $^3P_1 \rightarrow {}^1S_0$ ($\Delta S=1$)
1(e)	18 keV
1(f)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^2$
1(g)	3/2
1(h)	0.29
1(i)	Yes. (Gain required for lasing < 5 m^{-1})
1(j)	2.9×10^5
2	(c) 3.3 (d) 6.7 keV (f) 12.4 (g) One. ($2s \rightarrow 1s$ is forbidden.)
3	(d) 51 cm^{-1}, assuming Z^2 scaling. (f) $^2P_{1/2} \rightarrow {}^2S_{1/2}$: four lines; $^2P_{3/2} \rightarrow {}^2S_{1/2}$: six lines ($F=5 \rightarrow 3$ and $F=2 \rightarrow 4$ forbidden)
4	(c)(i) Three lines: ΔE / $\mu_B B = \pm1, 0$ (c)(ii) Six lines: ΔE / $\mu_B B = \pm2, \pm3/2\mu_B B, \pm1/2$ ($M_J = 0 \rightarrow 0$ forbidden) (e) ^{39}K and ^{41}K
5	(d)(ii) environmental broadening or phonon broadening, or both (d)(iii) 8×10^{-13} s; ~ 1000 modes

Autumn Semester 2015-16

Question	Answer
1(a)	5.10 eV
1(b)	430.6655 nm
1(c)	$^4D_{3/2} \rightarrow {}^2P_{1/2}$ ($\Delta S=1$)
1(d)	3.20
1(e)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^3$
1(f)	0.13 nm
1(g)	Four lines, shifted by $-4/3$, $-2/3$, $+2/3$, and $+4/3$ in units of $\mu_B B$ relative to $h\nu_0$
1(h)	0.029 m^{-1}
1(i)	2.9×10^{-20} N
2	(e) (i) 3.8 MHz, (ii) 570 MHz (f) 1.6×10^6 K
3	(b) (i) $4s^2$: $^1S_0$; (b)(i) 3d4s: $^1D_2$, $^3D_3$, $^3D_2$, $^3D_1$; (b)(i) $3d^2$: $^1G_4$, $^3F_4$, $^3F_3$, $^3F_2$, $^1D_2$, $^3P_2$, $^3P_1$, $^3P_0$, $^1S_0$ (the electrons are equivalent, so $L+S$ = even) (b) (ii) all forbidden, e.g. by $\Delta l = \pm\ 1$ rule (b)(iii) $^3D_1$ (b)(iv) smaller (c) $\sigma_K = 2.8$; $\sigma_L = 8.9$; L shell has three sub shells: 2s, 2p(j=3/2, 1/2)
4	(a)(ii) 3.01×10^{-6} m, 3.50×10^{-6} m, 3.62×10^{-6} m (a)(iii) 66 cm^{-1} (0.0082 eV), assuming Z^2 scaling. (b)(i) $M_J = +1/2$ (b)(ii) 1.98×10^{-7} K; 3.5 mm s^{-1}
5	(d)(ii) 0.82; inverted ($N_2/N_1 > 1/3$) (d)(iii) 0.02 m (d)(iv) 2.0 m (d)(v) 1.3×10^{-12} s

Autumn Semester 2014-15

Question	Answer
1(a)	656 nm
1(b)	794.98 nm, 1.5596 eV
1(c)	$^4I_{11/2} \rightarrow {}^4H_{7/2}$ (ΔJ=2), $^3F_3 \rightarrow {}^3P_2$ (ΔL=2), $^3D_1 \rightarrow {}^1P_1$ (ΔS=1)
1(d)	17.6 keV
1(e)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^3$; $^4S_{3/2}$
1(f)	S =0; $\sum s_i$ cannot be zero for an odd number of electrons
1(g)	0.46 N_0
1(h)	-3.0×10^4 K
2	(a) 4.389×10^5 cm^{-1} (b)(ii) $5/2\ a_0$ (c) 54.4 eV; other electron partly screens the nucleus in neutral He (d)(i) $^1S_0$ (d)(ii) $1s^2\ ^1S_0 \rightarrow 1snp\ ^1P_1$, with n= 2, 3 and 4
3	(b) (i) yes; (ii) no (c) spin-orbit coupling splits the p states into two J states (e)(i) 4; (ii) 6
4	(b) $\Delta\nu_{natural}$ = 5 MHz, and low pressure, so both negligible. Hence Doppler broadening - inhomogeneous. T = 397 K (c) 0.002 nm (e)(i) 0.028 m^{-1} ; (ii) 500 MHz
5	(b)(i) -2.6×10^{-20} N; (ii) 1.9 ms; (iii) 0.20 m; (iv) 2.5×10^{-4} K (assuming Doppler limit) (d)(i) 4.0×10^{-7} K; (ii) No BEC: ^{40}K is a fermion; (iii) 1.2×10^{-8} K; (iv) 1.3×10^{-7} K