PHY332: Numerical answers to past exam papers

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)	654 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

Autumn Semester 2013-14

Question	Answer
1(a)	468.7nm
1(b)	518.51nm, 2.391 eV
1(c)	$^2D_{3/2} \rightarrow {}^2S_{1/2}$ ($\Delta L=2$), $^4P_{5/2} \rightarrow {}^2D_{3/2}$ ($\Delta S=1$), $^3F_2 \rightarrow {}^3G_5$ ($\Delta J=3$)
1(d)	20.7 keV
1(e)	[Xe] $6s^2\ 4f^3$
1(f)	$^1D_2$, $^3D_3$, $^3D_2$, $^3D_1$, singlet has highest energy
1(g)	Five levels with $\Delta E = g_J \mu_B B M_J$
1(h)	8.9 MHz
1(i)	8.4×10^{-13} s
2	(b)(i) $\delta(0) = 5.17$, $\delta(1) = 4.59$ (b)(ii) 717 nm (b)(iii) 2.59 (d) 7.0×10^{-20} N, 1.8×10^{-6} ms^{-2}
3	(b) J, I, F (c)(ii) L or S = 0, or both (d)(i) $^3P_0$ (d)(ii) $^1P_1$, $^3P_0$, $^3P_1$, $^3P_2$; $^3P_1 \rightarrow {}^3P_0$
4	(b)(i) 12 T (b)(ii) Four lines with wavelengths: 330.285, 330.291, 330.304, 330.311nm (c) 8.9×10^6 Vm^{-1}, positive
5	(c) -1.03×10^5 K (e)(i) Gain to oscillate = $1200m^{-1}$ (e)(ii) 24 mA.