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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2014/2015

COURSE NAME	:	LASER TECHNOLOGY
COURSE CODE	:	BWC 31403
PROGRAMME	:	3 BWC
EXAMINATION DATE	:	JUNE 2015 / JULY 2015
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **FOUR (4)** PAGES

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Q1 (a) Define the acronym LASER

(2 marks)

(b) Define ground state and excited state

(4 marks)

(c) With the aid of suitable diagrams, describe three ways (absorption, spontaneous emission and stimulated emission) in which an incident radiation can interact with the energy levels of atoms.
[Hint: note the frequency for each]

(14 marks)

Q2 (a) (i) Give 3 characteristics of laser beam.
(ii) Describe each characteristic.

(12 marks)

(b) (i) Define population inversion for a semiconducting laser (diode)
(ii) Explain the condition of population inversion.

(8 marks)

Q3 (a) Define spontaneous and stimulated emission

(6 marks)

(b) How does laser work?
[Hint: describe with the aid of suitable diagram]

(14 marks)

Q4 There have many factors that affect the shape and width of a line and thus affect the gain coefficient. Describe briefly the two generic classifications of processes that contribute to the width of a spectral line.

(20 marks)

Q5 Mode locking is a self-consistent self-reproducible pulse where the pulse is repeating at any point in the cavity. Explain the principle on how to generate the laser mode locking.
[Hint: use the geometry of the external modulator and the gain media AND the diagram of time and frequency domain representation of mode locked laser]

(20 marks)

Q6 Use the data of **Table Q6** to compute the following parameters for the helium-neon laser system. Assume low-pressure gas with Doppler broadening being dominant (T = 400°C) and a homogeneous linewidth of 50 MHz,.

(a) Stimulated emission cross section for the following transitions: $\lambda = 3.39$ μm, $\lambda = 1.1523$ μm, and $\lambda = 0.6328$ μm. Name the transitions.

(3 marks)

(b) What are the radiative lifetimes of the $3s_2$ and $2s_2$ states of neon?

(4 marks)

(c) Assume a laser tube 50 cm long with a population difference $[N_2 - (g_2/g_1)N_1]$ equal to 10^{10} cm^{-3} for each of the transitions listed above. Determine the maximum intensity that can be extracted from this laser on three transitions?

(7 marks)

(d) The laser sequence $3s_2 \rightarrow 3p_4 \rightarrow 2s_2 \rightarrow 2p_4$ is sometimes called the push-pull laser. Why? What wavelengths are generated?

(6 marks)

\- **END OF QUESTION** -

FINAL EXAMINATION

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Table Q6 Data Associated with the Various States of Neon

Transition	J_{upper}	J_{lower}	λ (Å)	$A(10^6\ sec^{-1})$	Relative Intensity
$3s_2 \rightarrow 2p_1$	1	0	7304.9	0.48	30
$3s_2 \rightarrow 2p_2$	1	1	6401.1	0.6 (est.)	100
$3s_2 \rightarrow 2p_3$	1	0	6351.9	0.7	100
$3s_2 \rightarrow 2p_4$	1	2	6328.2	6.56	300 (common "red" laser)
$3s_2 \rightarrow 2p_5$	1	1	6293.8	1.35	100
$3s_2 \rightarrow 2p_6$	1	2	6118.0	1.28	100
$3s_2 \rightarrow 2p_7$	1	1	6046.1	0.68	50
$3s_2 \rightarrow 2p_8$	1	2	5939.3	0.56	50
$3s_2 \rightarrow 2p_9$	1	3	5882.5	Forbid $\Delta J = 2$	Not observed
$3s_2 \rightarrow 2p_{10}$	1	1	5433.6	0.59	250
$3s_2 \rightarrow \Sigma 2p$	1	—	Red-orange	12.8	—
$3s_2 \rightarrow 3p_4$	1	2	33913	2.87	-
$3s_2 \rightarrow \Sigma 3p$	1	—	IR	5.24	—
$2p_4 \rightarrow 1s_2$	2	1	6678.3	23.8	500
$2p_4 \rightarrow 1s_3$	2	0	6234.5	Forbid $\Delta J = 2$	Not observed
$2p_4 \rightarrow 1s_4$	2	1	6096.2	16.9	300
$2p_4 \rightarrow 1s_5$	2	2	5944.8	10.5	500
$2p_4 \rightarrow \Sigma 1s$			Red-orange	51.2	

Other transitions	ΣA		λ	$A(\times 10^6)$
$2p_1 \rightarrow \Sigma 1s$	87.9	$2s_2 - 2p_1$	1.5231 μm	0.802
$2p_2 \rightarrow \Sigma 1s$	116.6	$2p_2$	1.1767 μm	4.089
$2p_3 \rightarrow \Sigma 1s$	61.7	$2p_3$	1.1602 μm	0.801
$2p_4 \rightarrow \Sigma 1s$	51.7	$2p_4$	1.1523 μm	6.537 (first gas laser)
$2p_5 \rightarrow \Sigma 1s$	53.3	$2p_5$	1.1409 μm	2.301
$2p_6 \rightarrow \Sigma 1s$	53.6	$2p_6$	1.0844 μm	7.543
$2p_7 \rightarrow \Sigma 1s$	49.3	$2p_7$	1.0621 μm	0.816
$2p_8 \rightarrow \Sigma 1s$	41.2	$2p_8$	1.0295 μm	0.726
$2p_9 \rightarrow \Sigma 1s$	43.3	$2p_9$	Forbidden	—
$2p_{10} \rightarrow \Sigma 1s$	33.6	$2p_{10}$	0.8895 μm	1.708