THE OPEN UNIVERSITY OF SRI LANKA

B. Sc. Degree Programme — Level 4
Assignment I (Test) — 2014/2015
CMU 2220/CME 4220 — Concepts in Chemistry

1 hour

31st January 2015 (Saturday) 1.00 p.m. — 2.00 p.m.

- Answer all 25 questions (25 x 4 = 100 marks)
- Choose the most correct answer to each of the questions and mark this answer with an "X" on the answer script in the appropriate box.
- Use a **PEN** (not a PENCIL) in answering.
- Any answer with more than **one** "X" marked will be considered as an *incorrect* answer.
- Marks will be deducted for incorrect answers (0.6 per incorrect answer).
- The use of a non-programmable electronic calculator is permitted.
- Mobile phones are **not** allowed.

Gas constant (R)	=	$8.314\ JK^{-1}mol^{-1}$
Avogadro constant (N_A)	=	$6.023\times10^{23}\ mol^{-1}$
Faraday constant (F)	=	$96,500\ Cmol^{-1}$
Planck constant (h)	=	$6.63\times10^{-34}\ Js$
Velocity of light (c)	=	$3.0\times10^{8}\ ms^{-1}$
Protonic charge (e)	=	$1.602177\times10^{-19}\ C$
Standard atmospheric pressure	=	$10^{5}\ Pa\left(Nm^{-2}\right)$
$Log_e(X)$	=	$2.303\ Log_{10}(X)$

1. Consider the following statements about a beam of electromagnetic radiation having only two types of photons with wavenumbers $1500\ cm^{-1}$ and $2000\ cm^{-1}$.

   (i) It has photons of energy $1.98\times10^{-20}\ J$.

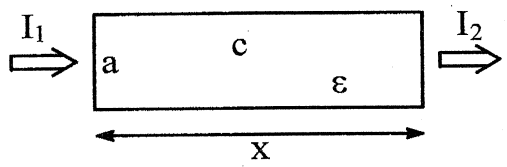
   (ii) It is not a monochromatic beam of radiation.

   (iii) It has photons of frequency approximately equal to $4.5\times10^{13}\ Hz$.

   The correct statements out of (i), (ii) and (iii) above are
   (a) Only (i) and (ii). (b) Only (i) and (iii). (c) Only (ii) and (iii).
   (d) All (i), (ii) and (iii) (e) None of the answers (a), (b), (c) or (d) is correct.

Use the following data in answering questions 2, 3, 4, 5 and 6.

A beam of monochromatic radiation of intensity $I_1 = 1.0\times10^{-5}$ W m^{-2} and frequency 3.5×10^{12} Hz enters a solution of a compound, Q, in a sample cell of uniform cross sectional area, $a = 2.0$ cm^2 and path length $x = 1.5$ cm. (See the figure to the right.) The concentration and the molar extinction coefficient of Q is c and ε, respectively. The intensity of the outgoing beam of radiation is I_2. The transmittance, T, of the above mentioned sample is 1/2.



2. Consider the following relationships.

(i) $I_1/I_2 = 2$ (ii) $\varepsilon c x = 2$ (iii) $I_2 = I_1\times10^{-\varepsilon c x}$

The correct relationships out of (i), (ii) and (iii) above are
(a) Only (i) and (ii). (b) Only (i) and (iii). (c) Only (ii) and (iii).
(d) All (i), (ii) and (iii) (e) None of the answers (a), (b), (c) or (d) is correct.

3. Which of the following best represents the intensity, I_2, of the outgoing beam.?

(a) 1.5×10^{-5} W m^{-2} (b) 5.0×10^{-6} W m^{-2} (c) 6.67×10^{-6} W m^{-2}
(d) 2.0×10^{-5} W m^{-2} (e) 3.0×10^{-5} W m^{-2}

4. Which of the following best represents the number of photons entering the sample in unit time?

(a) 4.3×10^{15} s^{-1} (b) 8.6×10^{15} s^{-1} (c) 6.45×10^{15} s^{-1}
(d) 4.3×10^{11} s^{-1} (e) 8.6×10^{11} s^{-1}

5. Which of the following best represents the number of photons absorbed by the sample (per second)?

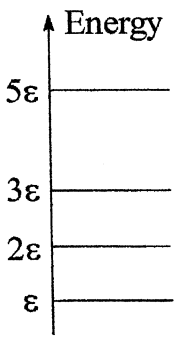
(a) 4.3×10^{15} s^{-1} (b) 8.6×10^{15} s^{-1} (c) 6.45×10^{15} s^{-1}
(d) 4.3×10^{11} s^{-1} (e) 8.6×10^{11} s^{-1}

6. Which of the following best represents the number density of photons in the outgoing beam?

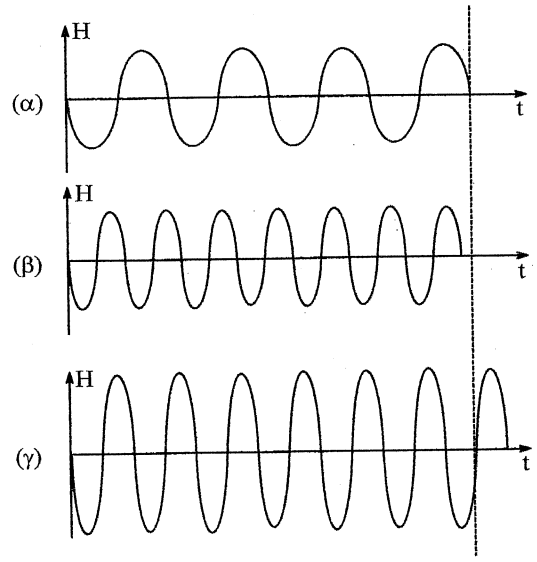
(a) 1.43×10^{7} s^{-1} (b) 2.87×10^{7} s^{-1} (c) 2.15×10^{7} s^{-1}
(d) 1.43×10^{3} m^{-3} (e) 2.87×10^{3} s^{-1}

7. A (hypothetical) molecule has only 4 energy levels as shown in the figure to the right. What is the maximum number of peaks that may be observed in the absorption spectrum of this molecule?

(a) 3 (b) 6 (c) 5 (d) 7 (e) 4



8. The magnetic field strength, H, versus time, t, drawn on the same scales, of three different monochromatic parallel beams of radiation, (α), (β) and (γ) are shown in the figure.



Consider the following statements about these three beams.

(i) Photons in beam (β) has the highest energy.

(ii) Radiation in beam (α) has the lowest frequency.

(iii) Highest rate of flow of energy is in beam (γ).

The correct statements out of (i), (ii) and (iii) above are

(a) Only (i) and (ii). (b) Only (i) and (iii). (c) Only (ii) and (iii).
(d) All (i), (ii) and (iii) (e) None of the answers (a), (b), (c) or (d) is correct.

9. A student filled the two identical sample cells in a double beam spectrometer with deionised water and adjusted the absorbance reading to zero when the frequency of the incident beam is ν_1. Then he discarded the water in the sample cells, rinsed them with an aqueous solution of a compound X, filled them with the same solution of X and placed them in the same positions in the double beam spectrometer. He then recorded the absorbance reading at two frequencies ν_1 and ν_2 (without making any changes to the two sample cells). It is known that X has non-zero molar extinction coefficients at the frequencies ν_1 and ν_2. Consider the following statements.

The absorbance reading observed by the student in the spectrometer at frequency

(i) ν_1 is zero.

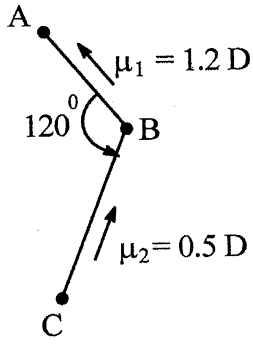
(ii) ν_2 is not zero.

(iii) ν_1 will not be zero if the solution X in one of the sample cells is replaced with deionised water.

The correct statements out of (i), (ii) and (iii) above are

(a) Only (i) and (ii). (b) Only (i) and (iii). (c) Only (ii) and (iii).
(d) All (i), (ii) and (iii) (e) None of the answers (a), (b), (c) or (d) is correct.

10. The dipole moments (with their directions) of the two bonds in a molecule, with molecular formula ABC, are shown in the figure to the right. ABC bond angle in 120^0. What is the dipole moment of the molecule? $\left[\cos\left(120^0\right)=-0.5,\ \sin\left(120^0\right)=\sqrt{3}/2\right]$



(a) 1.09 D (b) 2.30 D (c) 1.10 D
(d) 2.29 D (e) 1.99 D

11. Two students, X and Y, measured the absorbance of two different samples of the same gaseous compound using two different spectrometers. Their absorbance readings were 0.5 and 0.9 respectively. Consider the following statements which may explain the difference in absorbance obtained by X and Y.

(i) The temperature of the samples used by X and Y may have been different.

(ii) The pressure of the samples used by X and Y may have been different.

(iii) The path lengths of the cells used by X and Y may have been different.

Acceptable explanations out of (i), (ii) and (iii) above are

(a) Only (i) and (ii). (b) Only (i) and (iii). (c) Only (ii) and (iii).
(d) All (i), (ii) and (iii) (e) None of the answers (a), (b), (c) or (d) is correct.

12. Consider the following statements.

(i) The permanent dipole moment of any homonuclear diatomic molecule is zero.

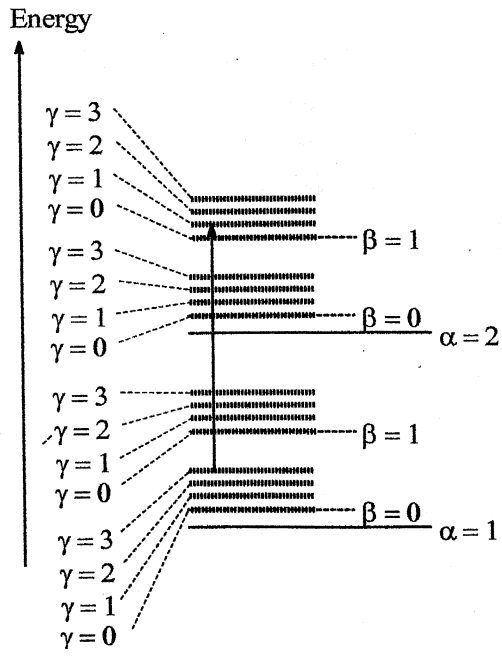
(ii) Any homonuclear diatomic molecule can have an induced dipole moment.

(iii) A heteronuclear diatomic molecule cannot have an induced dipole moment.

The correct statements out of (i), (ii) and (iii) above are

(a) Only (i) and (ii). (b) Only (i) and (iii). (c) Only (ii) and (iii).
(d) All (i), (ii) and (iii) (e) None of the answers (a), (b), (c) or (d) is correct.

13. The first two electronic energy levels, the first two vibrational energy levels associated with each of these electronic energy levels and the first 4 rotational energy levels associated with each of these vibrational energy levels of a molecule are shown in the figure to the right. The quantum numbers α, β and γ are used to identify the electronic, vibrational and rotational energy levels, respectively. As usual, the total energy levels of the molecule may be identified using the same three quantum numbers as (α, β, γ). Which of the following best represents the energy transition shown by the vertical arrow in the figure?



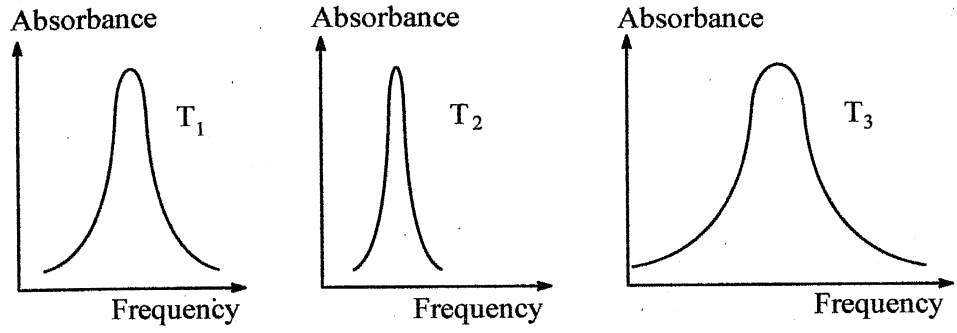
(a) $(1,1,3) \rightarrow (2,1,1)$ (b) $(1,1,3) \rightarrow (2,1,2)$ (c) $(1,0,3) \rightarrow (2,0,1)$
(d) $(1,1,3) \rightarrow (2,0,1)$ (e) $(1,0,3) \rightarrow (2,1,1)$

14. A molecule undergoes stimulated emission process due to an incoming photon of energy 2.9835×10^{-20} J. What is the wavenumber of the emitted photon?

(a) 1500 cm^{-1} (b) 3000 cm^{-1} (c) 4500 cm^{-1}
(d) 1000 cm^{-1} (e) 750 cm^{-1}

Use the following data in answering questions 15 and 16.

A peak in the absorption spectrum of a gaseous sample of a compound Q, obtained using a double beam spectrometer, at three different temperatures, T_1, T_2 and T_3 (keeping all the other experimental conditions the same) drawn on the same frequency and absorbance scales, are shown below.



15. Which of the following best represents the most probable relationship among the temperatures?

(a) $T_1 > T_2 > T_3$ (b) $T_1 < T_2 < T_3$ (c) $T_3 = T_2 < T_1$

(d) $T_1 < T_2 > T_3$ (e) $T_2 < T_1 < T_3$

16. Consider the following statements.

The broadening of the peak when going from $T_2 \rightarrow T_1 \rightarrow T_3$ may be due to

(i) Change in life time of the upper energy state due to spontaneous emission.

(ii) Doppler effect.

(iii) Change in life time of the upper energy state due to collisions among molecules of Q.

The correct statements out of (i), (ii) and (iii) above are

(a) Only (i) and (ii). (b) Only (i) and (iii). (c) Only (ii) and (iii).

(d) All (i), (ii) and (iii) (e) None of the answers (a), (b), (c) or (d) is correct.

17. Three microscopic processes, $(\alpha), (\beta)$ and (γ), that occur in a sample of molecules, M, placed in an absorption spectrometer are shown below in standard notation.

(α) $M^* \rightarrow M + h\nu$ (β) $M + h\nu \rightarrow M^*$ (γ) $M^* + h\nu_1 \rightarrow M + h\nu_1 + h\nu_2$

Process (γ) represents the stimulated emission process.

Consider the following statements about these processes.

(i) Process (β) is called spontaneous absorption.

(ii) $\nu_1 = \nu_2$ in process (γ).

(iii) In process (γ), $h\nu_2 = E_{initial} - E_{final}$ where $E_{initial}$ and E_{final} are the initial and final energy of the molecule M involved in stimulated emission process.

The correct statements out of (i), (ii) and (iii) above are

(a) Only (i) and (ii). (b) Only (i) and (iii). (c) Only (ii) and (iii).

(d) All (i), (ii) and (iii) (e) None of the answers (a), (b), (c) or (d) is correct.

18. If the rate of a reaction of the form $A + B \rightarrow P$ followed the rate law, $-\frac{d[A]}{dt} = k[A]^{1/2}[B]$, then the **SI** unit of k is,

(a) $mol^{-1/2}\,dm^{3/2}\,s^{-1}$ (b) $mol^{-1/2}\,m^{-3/2}\,s^{-1}$ (c) $mol^{-1/2}\,m^{3/2}\,s^{-1}$

(d) $mol^{-2}\,m^{6}\,s^{-1}$ (e) $mol^{-1/2}\,m^{3/2}\,min^{-1}$

19. Consider the following statements about the reaction: $N_2 + 3H_2 \rightarrow 2NH_3$

(i) Rate of formation of Ammonia is twice the rate of disappearance of Nitrogen.

(ii) Rate of disappearance of Hydrogen is thrice the rate of disappearance of Nitrogen.

(iii) The rate equation of the above reaction is $-\frac{d[N_2]}{dt} = k[N_2][H_2]^3$

The correct statements out of (i), (ii) and (iii) above are

(a) Only (i) and (ii). (b) Only (i) and (iii). (c) Only (ii) and (iii).

(d) All (i), (ii) and (iii) (e) None of the answers (a), (b), (c) or (d) is correct.

20. The following statements refer to a reaction of the form, $A + 2B + C \rightarrow P + Q$; its rate equation was experimentally determined as $-\frac{d[A]}{dt} = k[A][B]^2$

(i) The above reaction may be classified as an elementary reaction.

(ii) This reaction is zero order with respect to C.

(iii) The overall order of the reaction is 3.

(iv) If the concentration of A is in excess relative to B, it can be considered as a pseudo first order reaction.

The correct statements out of (i), (ii), (iii) and (iv) above are

(a) Only (ii) and (iii) (b) Only (ii), (iii) and (iv). (c) Only (iii), (iv) and (i).

(d) Only (ii) and (i) (e) Only (iii) and (iv)

In answering questions 21 and 22 use the following information on a first order reaction of the form $A \rightarrow$ Products carried out at $27^{\circ}C$.

Rate constant for the above reaction, $k = 2.0 \times 10^{-5}\ min^{-1}$

The initial concentration of A, $a = 5.0 \times 10^{-2}\ mol\ dm^{-3}$

21. The integrated form of the rate equation for this reaction is (where **x** is the concentration of A reacted after time, **t**)

(a) $\frac{1}{[a]} - \frac{1}{[a-x]} = kt$ (b) $x = kt$ (c) $\left[\frac{x}{a(a-x)}\right] = kt$

(d) $\left[\frac{a}{x(a-x)}\right] = kt$ (e) $\ln\left[\frac{a}{a-x}\right] = kt$

22. The half – life of the above reaction (in minutes) is about

(a) 35 (b) 70 (c) 35×10^3 (d) 1×10^3 (e) 1×10^6

23. Consider the following statements.

(i) According to Arhennius equation, rate constant is proportional to $\exp\left(\frac{E_a}{RT}\right)$.

(ii) According to Arhennius equation, a plot of $\ln(k)$ versus $\frac{1}{T}$ is a straight line.

(iii) The gradient from the plot in (ii) above is $-\frac{E_a}{R}$

The correct statement/s out of (i), (ii) and (iii) above is/are

(a) Only (ii) (b) Only (iii) (c) Only (i) and (iii).
(d) Only (ii) and (iii) (e) All (i), (ii) and (iii)

24. Consider the following reaction scheme.

$$RCHO \xrightarrow{k_1} R^* + CHO$$

$$R^* + RCHO \xrightarrow{k_2} RH + RCO$$

$$RCO \xrightarrow{k_3} R^* + CO$$

$$2RCO \xrightarrow{k_4} RCOCOR$$

Applying the steady state assumption for the radical, R^*, the expression obtained for the concentration of R^* is

(a) $[R^*] = \frac{k_3[RCO] - k_1[RCHO]}{k_2[RCHO]}$ (b) $[R^*] = \frac{k_3[RCO] + k_1[RCHO]}{k_2[RCHO]}$

(c) $[R^*] = \frac{k_3[RCHO] + k_1[RCO]}{k_2[RCHO]}$ (d) $[R^*] = k_3[RCO] + k_1[RCHO] - k_2[RCHO]$

(e) $[R^*] = \frac{k_3[RCO] + k_4[RCO]^2}{k_2[RCHO]}$

25. A kinetic experiment involving the hydrolysis reaction between methyl acetate and sodium hydroxide was carried out. You have been asked to mix 10.00 cm^3 of methyl acetate with distilled water and 2.0 M NaOH such that the total volume is 250.0 cm^3 and the concentration of NaOH equals that of methyl acetate.

[Assume that the density of methyl acetate = 740.0 kg m^{-3} and relative atomic masses: H= 1.0; C = 12.0; O = 16.0]

The initial concentration of ester $\left(\text{in mol } m^{-3}\right)$ in the reaction mixture is

(a) 0.1×10^3 (b) 4.0×10^{-1} (c) 4.0×10^2
(d) 4.0×10^3 (e) 4.0×10^{-3}

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Assignment I (Test) — 2014/2015

CMU 2220/CME 4220 — Concepts in Chemistry

MCQ Answer Sheet: Mark a cross (×) over the box that corresponds to the most suitable answer.

Reg. No.

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Answers	**No.**	**Marks**
Correct		
Wrong		–
Unmarked		0.0
Total		

1	a	b	c	d	e	2	a	b	c	d	e	3	a	b	c	d	e	4	a	b	c	d	e
5	a	b	c	d	e	6	a	b	c	d	e	7	a	b	c	d	e	8	a	b	c	d	e
9	a	b	c	d	e	10	a	b	c	d	e	11	a	b	c	d	e	12	a	b	c	d	e
13	a	b	c	d	e	14	a	b	c	d	e	15	a	b	c	d	e	16	a	b	c	d	e
17	a	b	c	d	e	18	a	b	c	d	e	19	a	b	c	d	e	20	a	b	c	d	e
21	a	b	c	d	e	22	a	b	c	d	e	23	a	b	c	d	e	24	a	b	c	d	e
25	a	b	c	d	e																		