THE OPEN UNIVERSITY OF SRI LANKA

B.Sc Degree Programme — Level 4

Assignment I (Test) — 2015/2016

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.

FOR EXAMINER'S USE ONLY		
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																		

THE OPEN UNIVERSITY OF SRI LANKA

B. Sc. Degree Programme — Level 4
Assignment I (Test) — 2015/2016
CMU 2220/CME 4220 — Concepts in Chemistry

1 hour

2nd April 2016 (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. Which of the following processes involve the absorption of electromagnetic radiation?

   (i) Photosynthesis.

   (ii) Conversion of solar energy into electrical energy using solar panels.

   (iii) Seeing an object by a human being.

   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.

2. The number of photons crossing an area of $2.0\ cm^2$ within 3s in a beam of a radiation having the wave length of 20 nm is 4.45×10^{9}. What is the intensity of the beam?

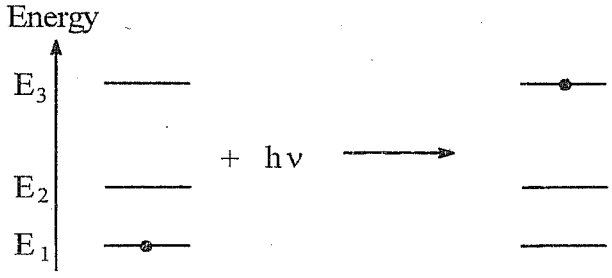
   (a) $1.48\times10^{-4}\ W\ s^{-1}$ (b) $2.21\times10^{-4}\ W\ s^{-1}$ (c) $1.48\times10^{-5}\ W\ s^{-1}$
   (d) $4.89\times10^{-5}\ W\ s^{-1}$ (e) $7.38\times10^{-5}\ W\ s^{-1}$

3. What is/are the physical property/properties of a molecule that absorption of microwaves can change?

   (a) Nuclear energy (b) Electronic energy (c) Vibrational energy
   (d) Rotational energy (e) Electronic and vibrational energy

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

Absorption of a photon, of frequency ν, by a molecule having only three energy levels, E_1, E_2 and E_3, is schematically represented (on an energy level diagram) in the figure in standard notation. Here, Planck constant is denoted by h.



4. Consider the following statements about the above mentioned absorption process.

   (i) The Bohr condition for the absorption is $E_1 - E_3 = h\nu$.

   (ii) $\nu > [E_2 - E_1]/h$.

   (iii) The process may be called stimulated absorption.

   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) Only (i).

5. Consider the following statements about the above mentioned absorption process.

   (i) The photon with frequency ν cannot bring about a transition $E_1 \rightarrow E_2$ in the molecule through stimulated absorption.

   (ii) $\nu < [E_3 - E_2]/h$.

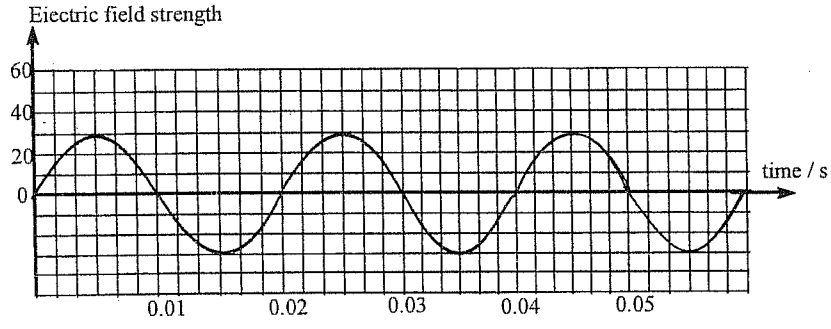
   (iii) The molecule in energy level E_3 may undergo spontaneous emission with the emission of a photon with frequency ν.

   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) Only (i).

6. Which of the following best represents the value of E_1, if $E_3 = 3.50\times10^{-21}$ J and $\nu = 2.50\times10^{12}$ Hz?

   (a) 1.55×10^{-21} J (b) 2.67×10^{-21} J (c) 1.00×10^{-21} J
   (d) 1.34×10^{-21} J (e) 1.84×10^{-21} J

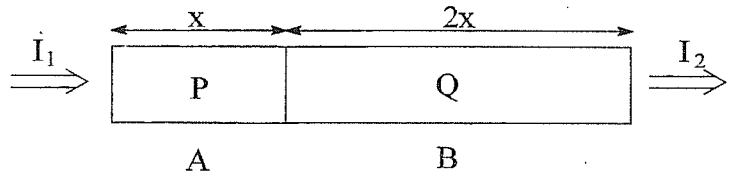
7. The electric field strength versus time of a particular monochromatic radiation is given in the figure to the right. What is the frequency of the radiation?



(a) 20Hz (b) 25Hz (c) 33.3Hz (d) 50Hz (e) 100Hz

Use the following data in answering questions 8, 9, 10 and 11.

A student filled two sample cells, A and B, with solutions of compounds P and Q, kept the two cells together and placed in this composite cell (i.e. A and B) in the path of a (parallel) beam of monochromatic electromagnetic radiation of frequency ν.



The intensity of the beam was $I_1 = 2.5\times10^{-5}\ \mathrm{W\,m^{-2}}$; see the figure. The intensity of the outgoing beam is I_2. The path lengths of the beam in A and B are x cm and 2x cm, respectively. The absorbance of the P and Q solutions in cells A and B are 0.8 and 0.2 respectively. The concentrations of P and Q in the solutions are $1.0\ \mathrm{mol\,dm^{-3}}$. The walls of the cells do not absorb radiation at frequency ν.

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

   (a) $3.0\times10^{-6}\ \mathrm{W\,m^{-2}}$ (b) $1.6\times10^{-5}\ \mathrm{W\,m^{-2}}$ (c) $2.5\times10^{-6}\ \mathrm{W\,m^{-2}}$

   (d) $3.5\times10^{-6}\ \mathrm{W\,m^{-2}}$ (e) $4.5\times10^{-6}\ \mathrm{W\,m^{-2}}$

9. Which of the following statements is true?

   (a) The molar extinction coefficient of Q is *greater* than that of P.

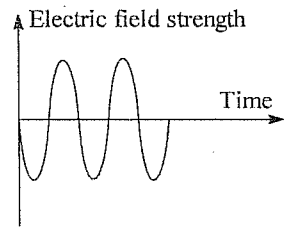
   (b) The molar extinction coefficient of Q is *less* than that of P.

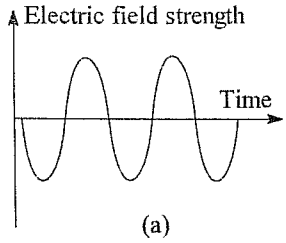
   (c) The molar extinction coefficient of Q is *equal* to that of P.

   (d) Given data is not sufficient to draw any conclusions about the relative magnitude of the molar extinction coefficients of P and Q.

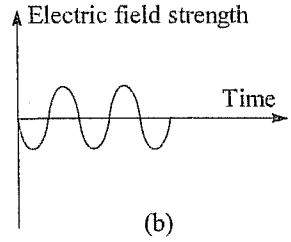
   (e) None of the above statements is true.

10. The electric field strength versus time of the incident radiation beam (at a point in space) with intensity I_1 is shown in the figure to the right. What figure best represents the electric field strength versus time of the outgoing beam of intensity I_2, on the same field strength and time scales.

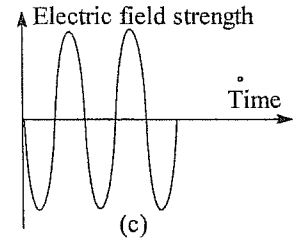




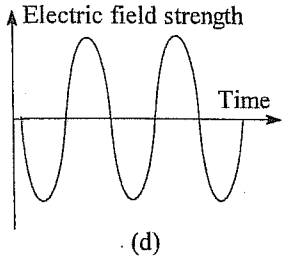
(a)



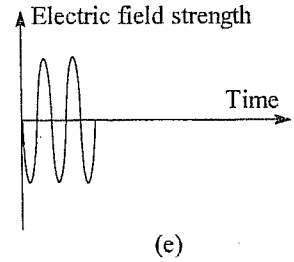
(b)



(c)



(d)



(e)

11. Another student altered the above mentioned arrangement. The only change he made was to place cell B in front of cell A so that B is exposed to the incoming beam of radiation of intensity I_1. He measured the intensity of the outgoing beam (i.e. now from A) to be I_3. Consider the following statements about the new setup.

(i) The absorbance of B in the new setup should be greater than 0.2 since it is now directly exposed to the incoming beam.

(ii) $I_3 = I_2$

(iii) The number of photons absorbed in unit time by compound Q in B in the new setup is greater than the number of photons it absorbed in unit time in the old setup.

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

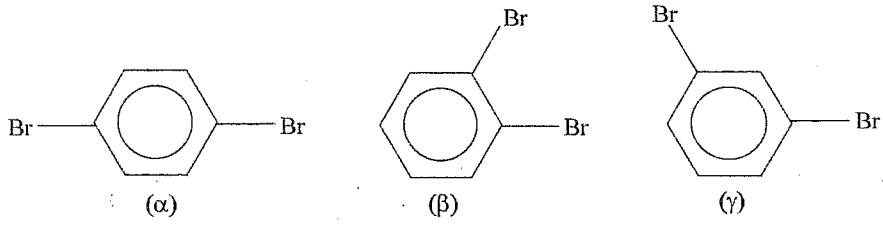
(a) Only (i) and (ii). (b) Only (i) and (iii). (c) Only (ii) and (iii).
(d) All (i), (ii) and (iii) (e) Only (i).

12. Which of the following best represents the bond distance of a diatomic molecule having dipole moment of 5.325 D and a partial charge of 0.802×10^{-19} C?

$\left[1\,\text{D} = 3.336\times10^{-30}\ \text{C m}\right]$

(a) 0.221 cm (b) 0.034 cm (c) 0.0.034 nm (d) 0.022 nm (e) 0.221 nm

13. Denote the dipole moments of the following molecules, α, β and γ, by μ_α, μ_β and μ_γ respectively.



(α) (β) (γ)

What is the correct relationship among the dipole moments?

(a) $\mu_\alpha < \mu_\beta < \mu_\gamma$ (b) $\mu_\alpha > \mu_\beta < \mu_\gamma$ (c) $\mu_\alpha > \mu_\beta > \mu_\gamma$
(d) $\mu_\alpha < \mu_\gamma < \mu_\beta$ (e) $\mu_\alpha < \mu_\beta = \mu_\gamma$

14. A student observed a peak, at frequency ν, in the spectrum of a gaseous sample of a diatomic molecule. Consider the following statements about his observation.

(i) Increasing temperature will shift the said peak to higher frequency.

(ii) Increasing pressure will increase the height of the peak.

(iii) Increasing temperature will increase the width of the peak.

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) Only (i).

15. What is the process indicated by the reaction, $M + h\nu \rightarrow M^*$?

(a) Stimulated absorption

(b) Stimulated emission

(c) Spontaneous emission

(d) Spontaneous absorption

(e) None of the answers (a), (b), (c) or (d) is correct

16. During an experiment a student observed that some molecules in a sample undergo stimulated emission when placed in a monochromatic beam of radiation of frequency ν. Consider the following statements about this experiment.

(i) The frequency of the radiation emitted during stimulated emission is ν.

(ii) Some molecules in the above mentioned sample have been in an excited state.

(iii) Some molecules in the sample may have undergone stimulated absorption during the above mentioned 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) Only (i).

17. The Boltzmann distribution function, in standard notation is given by the equation, $N_i = N_j\left(\frac{g_i}{g_j}\right)\mathrm{Exp}\left(-\frac{E_i - E_j}{kT}\right)$. Consider the following statements about this equation.

(i) N_i is the number of molecules in the energy level, i.

(ii) Always, one must make sure that $E_i > E_j$ in applying the equation.

(iii) g_j is the degeneracy of the energy level, j.

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) Only (i).

18. A certain reaction, $[A \rightarrow P]$ is found to follow the differential rate law, $-\frac{d[A]}{dt} = k[A]^3$.

The **SI unit** for the rate constant, k, for this reaction is

(a) $mol^{-2}\,dm^6\,s^{-1}$ (b) $mol^{-1}\,m^3\,s^{-1}$ (c) $mol^2\,m^6\,s^{-1}$

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

19. Given that the initial concentration of A is a, the expression for half life $[t_{1/2}]$ for the above reaction is

(a) $t_{1/2} = \frac{\ln(2)}{k}$ (b) $t_{1/2} = \frac{3}{2ka^2}$ (c) $t_{1/2} = \frac{1}{ka}$

(d) $t_{1/2} = \frac{3}{ka^2}$ (e) $t_{1/2} = \frac{a}{k}$

20. Which of the following equation corresponds the relationship between the rate constant and temperature according to Arrhenius?

(a) $k = A\,e^{-\frac{E}{RT}}$ (b) $\frac{d[A]}{dt} = k\,[A]$ (c) $A = k\,e^{\frac{E}{RT}}$

(d) $\ln(k) = e^{-\frac{E}{RT}}$ (e) $k = A\,e^{\frac{E}{RT}}$

21. Consider the following statements.

(i) The rate of an elementary reaction of the form $2B + C \rightarrow Q$ is proportional to $[B]^2[C]$

(ii) The overall order of the above reaction and its molecularity are the same.

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

(iv) The equilibrium constant, K, for a reversible reaction $A + B \underset{k_2}{\overset{k_1}{\rightleftharpoons}} C + D$ where k_1 and k_2 are the rate constants for the forward and backward reactions respectively is equal to $\frac{k_1}{k_2}$.

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

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

22. A kinetic experiment is carried out involving the hydrolysis reaction between an ester (relative molar mass = 72 and density $= 0.9\ g\ cm^{-3}$ = at 300 K) and sodium hydroxide. You have been asked to mix V cm^3 of the ester, 100 cm^3 of 2.5 M NaOH and distilled water such that the total volume is 250.0 cm^3 and the concentration of NaOH equals that of the alkyl acetate. The initial concentration of NaOH in the reaction mixture is

(a) 1.2 M (b) 1.0 M (c) 1.5 M (d) 0.25 M (e) 0.1 M

23. The value of V in Q question 23 above (in cm^3) is

(a) 25.0 (b) 50.0 (c) 30.0 (d) 15.0 (e) 20.0

[Continued in the next page]

Use the following data on the reaction, $X + Y \xrightarrow{k} Z$ in answering questions 24 and 25.

Kinetic study of the above reaction gave the following results.

$X/\text{mol dm}^{-3}$	$Y/\text{mol dm}^{-3}$	$\text{Rate} \times 10^5/\text{mol dm}^{-3}\ \text{s}^{-1}$
2.0	2.0	1.5
4.0	2.0	3.0
2.0	8.0	24.0

24. Which of one of the following best represents the rate law of the above reaction?

(a) $\text{Rate} = k[X][Y]$ (b) $\text{Rate} = k[X]^2[Y]$ (c) $\text{Rate} = k[X][Y]^3$

(d) $\text{Rate} = k[X][Y]^2$ (e) $\text{Rate} = k[X]^2[Y]^3$

25. The rate constant k $\left(\text{in mol}^{-2}\text{dm}^6\text{s}^{-1}\right)$ for the above reaction is,

(a) 3.75×10^{-6} (b) 3.75×10^{-5} (c) 1.875×10^{-6}

(d) 1.875×10^{6} (e) 1.875×10^{-5}