Department of Examinations, Sri Lanka
General Certificate of Education (Adv. Level) Examination, August 2015

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இரசாயனவியல் I
Chemistry I

02 E I

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இரண்டு மணித்தியாலம்
Two hours

Instructions:

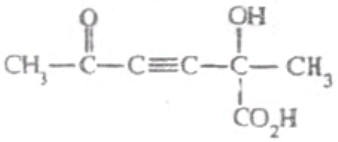
* *Periodic Table is provided.*
* *This paper consists of* **08** *pages.*
* *Answer* ***all*** *the questions.*
* ***Use of calculators is not allowed.***
* *Write your* ***Index Number*** *in the space provided in the answer sheet.*
* *Follow the instructions given on the back of the answer sheet carefully.*
* *In each of the questions* **1** *to* **50**, *pick one of the alternatives from* (1), (2), (3), (4), (5) *which is* ***correct or most appropriate*** *and* ***mark your response on the answer sheet with a cross*** (×) ***in accordance with the instructions given on the back of the answer sheet.***

Universal gas constant $R = 8.314\ J K^{-1} mol^{-1}$
Avogadro constant $N_A = 6.022 \times 10^{23}\ mol^{-1}$
Planck's constant $h = 6.626 \times 10^{-34}\ J s$
Velocity of light $c = 3 \times 10^{8}\ m s^{-1}$

1. The 'plum pudding' model of the atomic structure was put forward by
(1) John Dalton. (2) J. J. Thompson. (3) Glenn Seaborg.
(4) Ernest Rutherford. (5) Robert Millikan.

2. The **increasing** order of atomic/ionic radii of B, O, S, S^{2-} and Cl is
(1) $B < O < Cl < S < S^{2-}$ (2) $S < S^{2-} < O < B < Cl$
(3) $O < B < Cl < S < S^{2-}$ (4) $O < B < S < S^{2-} < Cl$
(5) $B < O < S < S^{2-} < Cl$

3. What is the IUPAC name of the compound X?
(1) 2-hydroxy-2-methyl-5-oxo-3-hexynoicacid
(2) 2-hydroxy-2-methyl-5-oxo-3-hexynoic acid
(3) 2-hydroxy-5-keto-2-methyl-3-hexynoic acid
(4) 5-carboxy-5-hydroxy-3-hexyn-2-one
(5) 2-carboxy-5-oxo-3-hexyn-2-ol



X

4. Which of the following statements regarding properties of atoms is **false**?
(1) The covalent radius of the iodine atom is smaller than its van der Waals radius.
(2) The first electron affinity of O atom is greater than that of N atom.
(3) The ionization energy of an atom is determined only by its nuclear charge and radius.
(4) The nuclear charge felt by the valence electron in a Li atom is less than 3.
(5) The electronegativity of C atom is the same as that of S atom in the Pauling scale.

5. Which of the following compounds has the **lowest** volatility?
(1) CBr_4 (2) $CHBr_3$ (3) CH_2Br_2 (4) CH_3Cl (5) CH_2Cl_2

6. A mixture of carbonates contains $MgCO_3$ and $CaCO_3$ in a 5 : 1 molar ratio respectively. When a known mass of this mixture is heated, the CO_2 formed occupied a volume of 134.4 dm^3 at standard temperature and pressure. The mass of the carbonate mixture heated is (C = 12, O = 16, Mg = 24, Ca = 40, At standard temperature and pressure one mole of gas occupies a volume of 22.4 dm^3.)
(1) 52 g (2) 520 g (3) 750 g (4) 900 g (5) 1040 g

7. A_3B_2 is a sparingly water soluble salt. At 25°C, its solubility and solubility product are s mol dm^{-3} and K_{sp} respectively. The **correct** expression for s is,
(1) $\left(\frac{K_{sp}}{36}\right)^5$ (2) $\left(\frac{K_{sp}}{36}\right)^{1/5}$ (3) $\left(\frac{K_{sp}}{72}\right)^{1/5}$ (4) $\left(\frac{K_{sp}}{108}\right)^{1/5}$ (5) $\left(\frac{K_{sp}}{108}\right)^5$

8. Which of the following reactions correctly represents a propagation step in the free radical chlorination reaction of methane?

(1) $Cl-Cl \xrightarrow{h\nu} Cl + Cl$ (2) $Cl\ Cl \longrightarrow Cl-Cl$

(3) $CH_3Cl-Cl \longrightarrow CH_3Cl + Cl$ (4) $H-CH_2Cl \longrightarrow CH_3Cl + H$

(5) $H-Cl\ CH_3 \longrightarrow CH_3Cl + H$

9. Which of the following statements is **false** with regard to the chemistry of Aluminium?

(1) Aluminium compounds are used as catalysts.
(2) Aluminium metal reacts with dilute HCl and form H_2 gas.
(3) The solution formed when solid Aluminium chloride is dissolved in water is basic.
(4) The shape around the Aluminium atoms in solid Aluminium chloride is tetrahedral.
(5) Aluminium chloride exists as a dimer in the solid state.

10. Which row of the following table gives the **correct** information with regard to the central S atom of the SSF_2 molecule?

	Oxidation state	Charge	Hybridization	Shape	Nature of S-S σ-bond in $S-SF_2$
(1)	+1	0	sp^3	Tetrahedral	S (3p a.o.) + S (sp^3 h.o.)
(2)	+2	0	sp^2	Trigonal planar	S (3p a.o.) + S (sp^2 h.o.)
(3)	+2	0	sp^3	Pyramidal	S (3p a.o.) + S (sp^3 h.o.)
(4)	+1	+1	sp^3	Pyramidal	S (3p a.o.) + S (sp^3 h.o.)
(5)	+2	+1	sp^2	Trigonal planar	S (3p a.o.) + S (sp^2 h.o.)

(a.o. = atomic orbital, h.o. = hybrid orbital)

11. A decomposes on heating to produce B and C according to the following equilibrium.

$$2A(g) \rightleftharpoons 2B(g) + C(g)$$

When a moles of pure A in a 1 dm^3 closed container is heated to a constant temperature T, the equilibrium mixture contained c moles of C. The **correct** expression for the equilibrium constant K_c for this reaction at temperature T is,

(1) $K_c = \frac{4c^3}{(a-2c)^2}$ (2) $K_c = \frac{4c^3}{(a-c)^2}$ (3) $K_c = \frac{c^3}{(a-c)^2}$ (4) $K_c = \frac{8c^3}{(a-2c)^2}$ (5) $K_c = \frac{c^2}{(a-2c)^2}$

12. Which of the following statements is **false** regarding the colours of complexes formed by 3d transition elements?

(1) $[Ni(NH_3)_6]^{2+}$ is deep blue in colour. (2) $[CuCl_4]^{2-}$ is pale blue in colour.
(3) $[NiCl_4]^{2-}$ is yellow in colour. (4) $[Co(NH_3)_6]^{2+}$ is yellow-brown in colour.
(5) $[CrCl_4]^-$ is blue-violet in colour.

13. A sample of liquid heptane (C_7H_{16}) weighing 10.0 g is mixed with 1.30 moles of O_2 gas. When heptane is burned **completely** a mixture of CO and CO_2 gases are formed. The total number of moles of gas present after the reaction (CO, CO_2 and O_2) is 1.1 at room temperature. (Assume that the water formed is present as a liquid and solubility of gases in it is negligible.) The moles of CO gas formed is,
(H = 1, C = 12, O = 16)

(1) 0.40 (2) 0.45 (3) 0.50 (4) 0.52 (5) 0.54

14. Consider a closed system in which pure liquid A is in equilibrium with its vapour at 27 °C. The enthalpy of vaporization of liquid A at this temperature is 20.00 kJ mol^{-1}. The entropy of vaporization of A in $JK^{-1}\ mol^{-1}$ at 27 °C is,

(1) 0.01 (2) 0.07 (3) 5.66 (4) 14.30 (5) 66.67

15. O_2 gas formed by the thermal decomposition of $KClO_3$ is collected by downward displacement of water. The volume of O_2 gas collected in such an experiment at 27 °C and 1.13×10^5 Pa pressure was 150.00 cm^3. Given that the saturated vapour pressure of water is 0.03×10^5 Pa at 27 °C, the mass of O_2 gas collected is, (O = 16)

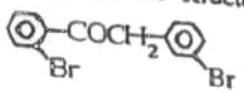
(1) 0.212 g (2) 0.217 g (3) 198 g (4) 212 g (5) 217 g

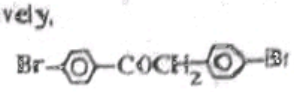
16. The pH value of a solution which contains a weak acid HA and its sodium salt NaA is a. If the value of the concentrations of HA to NaA ratio is increased ten times, the new pH value of the solution is,

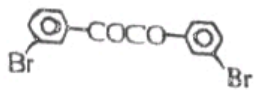
(1) $a-1$. (2) $a-1/10$. (3) $a+1$. (4) $a-10$. (5) $a+10$.

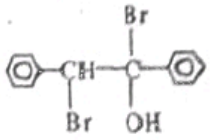
17. $C_6H_5-C\equiv C-C_6H_5 \xrightarrow[\text{dil. } H_2SO_4]{HgSO_4} A \xrightarrow[Br_2]{FeBr_3} B$

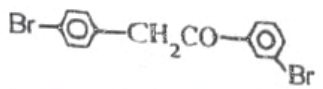
In the reaction scheme given above the structures of A and B are respectively,

(1) $C_6H_5COCH_2C_6H_5$ 

(2) $C_6H_5COCH_2C_6H_5$, 

(3) $C_6H_5COCOC_6H_5$, 

(4) $C_6H_5CH=C(OH)-C_6H_5$, 

(5) $C_6H_5CH_2COC_6H_5$, 

18. Select the answer with correct relationship for the rate of the reaction given below.

$2MnO_4^-(aq) + 5C_2O_4^{2-}(aq) + 16H^+(aq) \rightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(\ell)$

(1) $\frac{\Delta[MnO_4^-(aq)]}{\Delta t} = \frac{5}{2}\frac{\Delta[C_2O_4^{2-}(aq)]}{\Delta t}$

(2) $\frac{\Delta[MnO_4^-(aq)]}{\Delta t} = -\frac{5}{2}\frac{\Delta[C_2O_4^{2-}(aq)]}{\Delta t}$

3) $\frac{\Delta[MnO_4^-(aq)]}{\Delta t} = 10\frac{\Delta[C_2O_4^{2-}(aq)]}{\Delta t}$

(4) $\frac{\Delta[MnO_4^-(aq)]}{\Delta t} = \frac{2}{5}\frac{\Delta[C_2O_4^{2-}(aq)]}{\Delta t}$

(5) $\frac{\Delta[MnO_4^-(aq)]}{\Delta t} = -\frac{2}{5}\frac{\Delta[C_2O_4^{2-}(aq)]}{\Delta t}$

19 The potential and cell reaction of the following electrochemical cell at room temperature are respectively.

$Ag(s)/AgCl(s), KCl(aq)//Ag^+(aq)/Ag(s)$

($E^o_{AgCl(s)/Ag(s)} = +0.22\,V$ $E^o_{Ag^+(aq)/Ag(s)} = +0.78\,V$)

(1) +0.22 V , $AgCl(s) \longrightarrow Ag^+(aq) + Cl^-(aq)$ (2) +0.56 V , $Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$

(3) +1.0 V , $AgCl(s) + e \longrightarrow Ag(s) + Cl^-(aq)$ (4) −0.56 V , $Ag^+(aq) + e \longrightarrow Ag(s)$

(5) -1.0 V , $Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$

20 How many resonance structures can be drawn for the molecule N_2O_5 (skeleton $O-N-O-\overset{\overset{O}{|}}{N}-O$)?

(1) 5 (2) 6 (3) 8 (4) 9 (5) none of the answers given

21 Which of the following statements is false with regard to the chemistry of Zinc (Zn)?

(1) Zn is a non transition element with +2 as the most abundant and stable positive oxidation state.
(2) In general solutions of Zn complexes are colourless.
(3) The melting point of Zn is considerably high compared to that of other 3*d*-block elements.
(4) The radius of Zn^{2+} is smaller than that of Ca^{2+}
(5) ZnS cannot be precipitated by H_2S from acidic solutions.

22. Consider the following equilibrium that exists at a given temperature in a closed rigid container fitted with a valve.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

When an additional amount of $N_2(g)$ is introduced through the valve into the container the concentrations of $H_2(g)$ and $NH_3(g)$ respectively, will

(1) increase, increase. (2) decrease, decrease. (3) increase, decrease.
(4) decrease, increase. (5) not change, not change.

23. The reaction of CH_4 with excess O_2 to produce CO_2 and water is an exothermic process. The enthalpy change when 1 mole of CH_4 is reacted with O_2 under conditions where the water formed is in the liquid state is 890.4 kJ mol^{-1}. When this reaction is carried out under conditions where the water formed is in the vapour state, the enthalpy change is 802.4 kJ mol^{-1}. The enthalpy change (in kJ mol^{-1}) for the reaction $H_2O(l) \longrightarrow H_2O(g)$ is,

(1) −88 (2) −44 (3) 22 (4) 44 (5) 88

24. X is an element which belongs to the 3*d*-block. It shows the following properties.

I. It shows the highest positive oxidation state among the 3*d*-block elements.
II. It forms acidic, amphoteric and basic oxides.

X is

(1) Cr (2) Mn (3) Fe (4) Co (5) Zn

25. $CH_3COCH_2CO_2H \xrightarrow[(2)\ H_2O/H^+]{(1)\ LiAlH_4} S \xrightarrow{PCC} T \xrightarrow[Conc.\ HCl]{Zn/Hg} U$

In the reaction scheme given above, the structures of S, T, and U are respectively

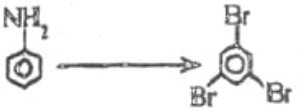
(1) $CH_3-\underset{OH}{CH}-CH_2CH_2OH$, CH_3COCH_2CHO, $CH_3CH_2CH_2CH_3$

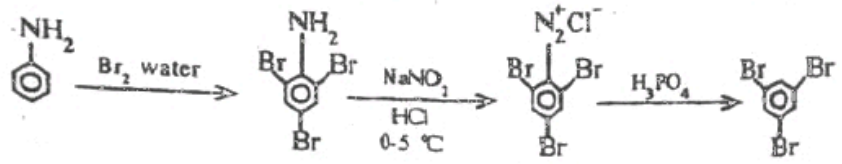
(2) $CH_3-\underset{OH}{CH}-CH_2CO_2H$, CH_3COCH_2CHO, $CH_3CH_2CH_2CH_3$

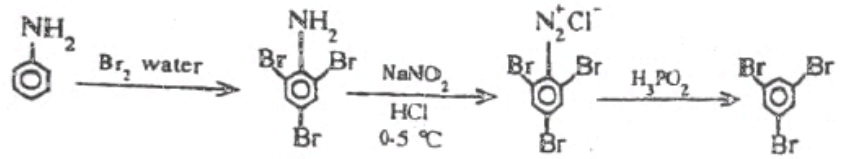
(3) $CH_3COCH_2CH_2OH$, CH_3COCH_2CHO, $CH_3CH_2CH_2CH_3$

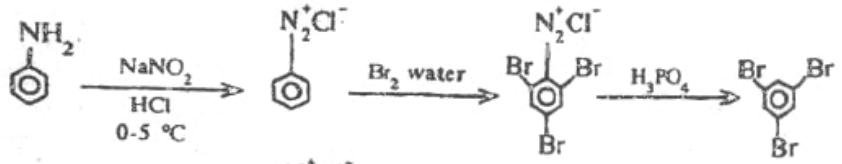
(4) $CH_3COCH_2CH_2OH$, CH_3COCH_2CHO, $CH_3COCH_2CH_3$

(5) $CH_3\underset{OH}{CH}-CH_2CH_2OH$, $CH_3\underset{OH}{CH}CH_2CHO$, $CH_3\underset{OH}{CH}CH_2CH_3$

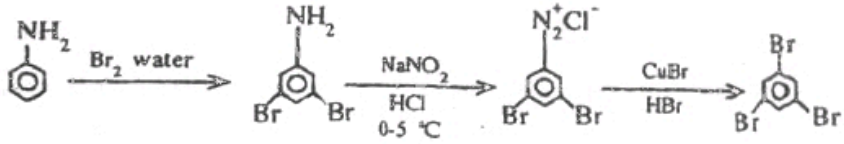
26. Which of the following methods is most suitable to transform,  ?

(1) 

(2) 

(3) 

(4) 

(5) 

27. Which of the following statements is true with regard to *s*-block elements (Group I, Li to Cs and Group II, Be to Ba) in the Periodic Table?

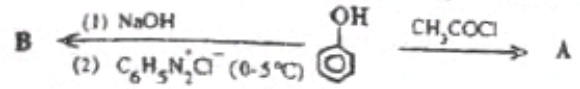
(1) All elements in Groups I and II react with water and give H_2 gas.
(2) All elements in Group I react with N_2 gas.
(3) Mg reacts with both dilute and concentrated H_2SO_4 and give H_2 (g) and SO_2 (g) respectively.
(4) Li reacts with air and forms a mixture of Li_2O, LiO_2 and Li_3N.
(5) All elements in Group I react with H_2 gas and form covalent hydrides.

28. Which of the following statements is **incorrect** with regard to a galvanic cell consisting of $Cd(s)/Cd^{2+}(aq)$ and $Zn(s)/Zn^{2+}(aq)$ electrodes?

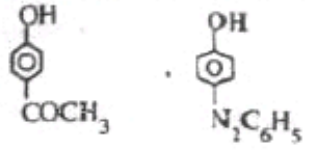
$E^{\circ}_{Zn^{2+}_{(aq)}/Zn_{(s)}} = -0.76\ V$, $E^{\circ}_{Cd^{2+}_{(aq)}/Cd_{(s)}} = -0.40\ V$

(1) The Zn electrode is the anode.
(2) When connected through an external circuit, electrons flow from the Zn electrode to the Cd electrode.
(3) Reduction occurs at the Zn electrode as the cell operates.
(4) The concentration of Cd^{2+} (aq) decreases as the cell operates
(5) The concentration of Zn^{2+} (aq) increases as the cell operates.

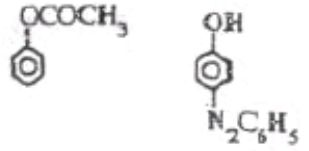
29. Consider the two reactions of phenol given below.



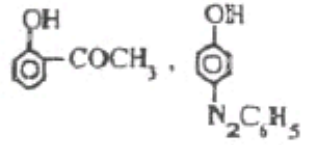
The structures of **A** and **B** are respectively

(1) 

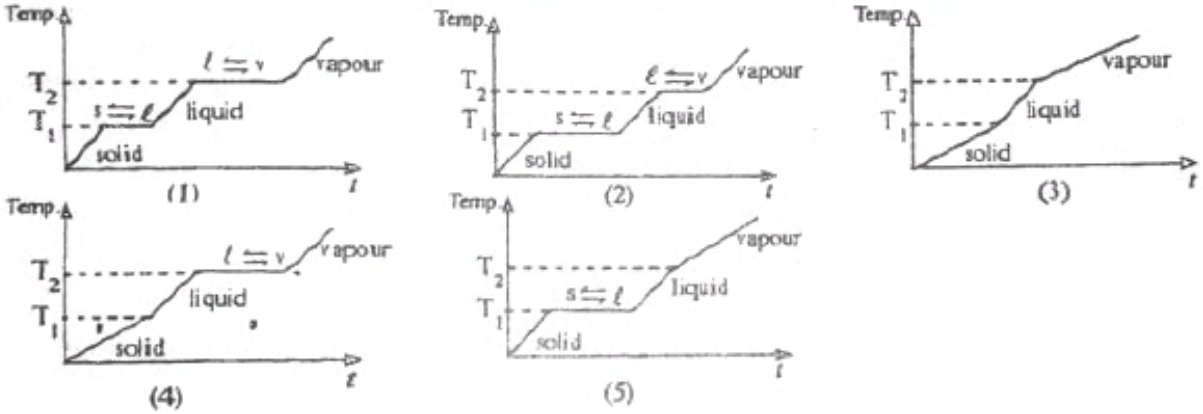
(2) 

(3) 

(4) 

(5) 

30. For the substance **X**, the magnitude of the value of ΔH_{fusion} is less than the magnitude of the value of $\Delta H_{vaporization}$ (i.e. $|\Delta H_{fusion}| < |\Delta H_{vaporization}|$). **X** melts at temperature T_1 and then vaporizes at temperature T_2 upon heating. Which diagram below best depicts the variation of temperature with time when a solid sample of **X** is heated at a constant rate? (**Note:** solid (s), liquid (ℓ), vapour (v))



○ For each of the questions 31 to 40, one or more responses out of the four responses (*a*), (*b*), (*c*) and (*d*) given is/are correct. Select the correct response/responses. In accordance with the instructions given on your answer sheet, mark

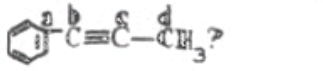
(1) if only (*a*) and (*b*) are correct.
(2) if only (*b*) and (*c*) are correct.
(3) if only (*c*) and (*d*) are correct.
(4) if only (*d*) and (*a*) are correct.
(5) if **any other** number or combination of responses is correct.

Summary of above Instructions

(1)	(2)	(3)	(4)	(5)
Only (*a*) and (*b*) are correct	Only (*b*) and (*c*) are correct	Only (*c*) and (*d*) are correct	Only (*d*) and (*a*) are correct	**Any other** number or combination of responses is correct

31. Which of the following statements is/are **false** with regard to the order of a reaction?

(*a*) The order of an elementary reaction should be a whole number.
(*b*) The order of a reaction is an experimentally determined value.
(*c*) The order of a reaction is always equal to the sum of the stoichiometric coefficients of the reactants in the balanced equation.
(*d*) The order of a reaction is the sum of the powers of the molar concentrations of the reactants in the rate law expression.

32. Which of the following statements is/are true regarding the molecule,  ?

(a) Carbon atoms labelled as a, b, c and d do not lie in a straight line.
(b) Carbon atoms labelled as a, b and d are sp^2, sp and sp^3 hybridized respectively.
(c) All carbon, carbon bond lengths of the benzene ring are equal to each other and are longer than the C≡C bond length.
(d) All carbon, carbon bond lengths of the benzene ring are equal to each other and are shorter than the C≡C bond length.

33. Which of the following statements is/are true with regard to the manufacture of NaOH using the membrane cell?

(a) During electrolysis $Na^+(aq)$ ions migrate from the cathode compartment to the anode compartment across the membrane.
(b) The anode and cathode used are titanium and nickel respectively.
(c) High purity NaOH can be prepared by this method.
(d) $H_2(g)$ and $Cl_2(g)$ are formed as by-products at the anode and cathode respectively.

34 Which of the following statements is/are false with regard to the activation energy of a reaction?

(a) The activation energy of the forward reaction in an exothermic process is lower than that of the backward reaction.
(b) The activation energy of a slow reaction is less than that of a fast reaction.
(c) The activation energy of a given reaction pathway is unaffected by a catalyst.
(d) The higher the initial concentration of reactants, the lower the activation energy.

35 Which of the following statements is/are true regarding stereoisomerism?

(a) A pair of stereoisomers which are mirror images of each other are known as enantiomers.
(b) A pair of stereoisomers which are mirror images of each other are known as diastereoisomers.
(c) A pair of stereoisomers which are not mirror images of each other are known as enantiomers.
(d) A pair of stereoisomers which are not mirror images of each other are known as diastereoisomers.

36 Which of the following statements is/are true for an electron that has quantum numbers $n = 3$ and $m_l = -2$?

(a) The electron is in the third main energy level.
(b) The electron is in a *d* orbital.
(c) The electron is in a *p* orbital.
(d) The electron must have a spin quantum number $m_s = +1/2$.

37 Most reactions take place more rapidly at high temperatures than at low temperatures. Which of the following statement(s) give(s) the correct reason(s) to explain this observation?

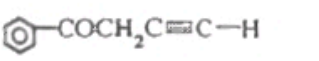
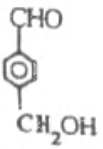
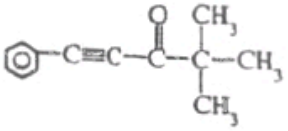
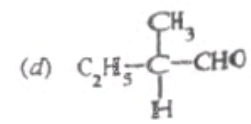
(a) The increase in temperature increases the activation energy of the reaction.
(b) The increase in temperature decreases the activation energy of the reaction.
(c) When the temperature increases the number of collisions per unit time per unit volume increases.
(d) The increase in temperature results in increasing the percentage of high energy collisions.

38 Which of the following statements is/are false with regard to the equilibrium constant K_c of an equilibrium reaction?

(a) It does not change when the pressure changes.
(b) It increases when the concentration of one product is increased.
(c) It can change with change in temperature.
(d) It increases when the concentration of one reactant is increased.

39. Which of the following compound/compounds undergo(es) both of the reactions given below?

I. Self condensation with aqueous NaOH.
II. Oxidation with ammoniacal $AgNO_3$.

(a) 
(b) 
(c) 
(d) 

40. Which of the following statements is/are true regarding polymers?

(a) PVC is a thermoplastic polymer and does not catch fire easily due to the presence of chlorine.
(b) Bakelite is formed by reaction of phenol and formaldehyde in the presence of conc. H_2SO_4.
(c) Urea and formaldehyde react in the presence of conc. H_2SO_4 to form a thermoplastic polymer.
(d) Teflon is a thermosetting polymer.

In question Nos. 41 to 50, two statements are given in respect of each question. From the Table given below, select the response out of the responses (1), (2), (3), (4) and (5) that best fits the two statements and mark appropriately on your answer sheet.

Response	First Statement	Second Statement
(1)	True	True, and correctly explains the first statement.
(2)	True	True, but does not explain the first statement correctly.
(3)	True	False
(4)	False	True
(5)	False	False

	First Statement	Second Statement
41.	NCl_3 can act as a bleaching agent in the presence of water.	NCl_3 reacts with water and gives NH_3 and HOCl.
42.	Vinyl chloride undergoes nucleophilic substitution reactions more easily than ethyl chloride.	Although the bond between carbon and chlorine in vinyl chloride has a double bond character due to resonance, this property is not present in ethyl chloride.
43.	The entropy of the surroundings goes down when water vapour condenses in a closed system.	Heat given out by a system increases the thermal motion of particles in the surroundings.
44.	The reaction of sulphur and NaOH is an example of a disproportionation reaction.	When an element is simultaneously oxidized and reduced, it is called disproportionation.
45.	Tertiary alcohols react faster than secondary alcohols in the Lucas test.	Tertiary carbocations are less stable than secondary carbocations.
46.	When a mixture of N_2O_4 and NO_2 in equilibrium in a closed system at a given temperature is cooled, the concentration of NO_2 increases.	The dissociation of N_2O_4 to NO_2 is an exothermic reaction.
47	In the Solvay process KCl can be used instead of NaCl.	$KHCO_3$ and $NaHCO_3$ have very similar solubilities in water.
48.	Phenol is an aromatic compound whereas ethanol is not.	The stability of the phenate ion relative to phenol is greater than the stability of the ethoxide ion relative to ethanol.
49.	$BaF_2(s)$ has a higher solubility in an aqueous acid medium than in water	When $BaF_2(s)$ is dissolved in an acid, due to the formation of HF, the $Ba^{2+}(aq)$ concentration increases in order to maintain K_{sp} constant.
50	Greenhouse gases prevent infra-red radiation emitted from the sun reaching the earth surface.	An ability to absorb infra-red radiation is an important feature of a greenhouse gas.

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