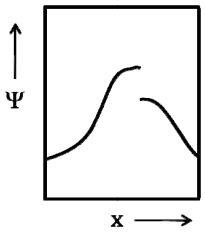
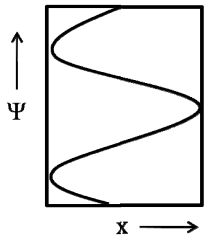
Useful information - CY Chemistry

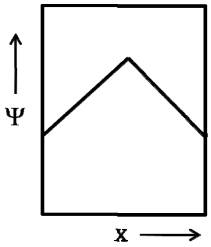
Avogadro constant	= 6.022×10^{23} mol^{-1}
Planck constant	= 6.626×10^{-34} J s
Mass of an electron	= 9.109×10^{-31} Kg
Charge of an electron	= 1.602×10^{-19} C
Universal gas constant	= 8.314 J K^{-1} mol^{-1} = 0.0831 L bar K^{-1} mol^{-1}
Boltzmann constant	= 1.38×10^{-23} J K^{-1}
1 atm pressure	= 101325 N m^{-2}
Faraday constant	= 96485 C mol^{-1}
2.303 RT/F at 298 K	= 0.059 V

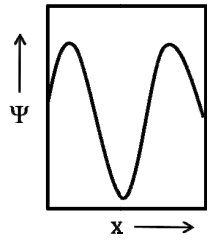
Q. 1 – Q. 25 carry one mark each.

Q.1 Which one of the following plots represents an acceptable wavefunction?

(A)


(B)


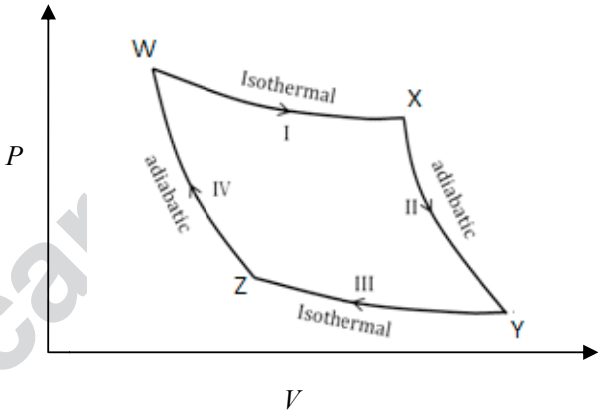
(C)


(D)


Q.2 When the operator, $-\hbar^2 d^2/dx^2$, operates on the function e^{-ikx}, the result is

(A) $k^2\hbar^2 e^{-ikx}$ (B) $ik^2\hbar^2 e^{-ikx}$ (C) $i\hbar^2 e^{-ikx}$ (D) $\hbar^2 e^{-ikx}$

Q.3



From the above Carnot cycle undergone by an ideal gas, identify the processes in which the change in internal energy is **NON-ZERO**.

(A) I and II (B) II and IV (C) II and III (D) I and IV

Q.4 For an ideal gas with molar mass M, the molar translational entropy at a given temperature is proportional to

(A) $M^{3/2}$ (B) $M^{1/2}$ (C) e^{M} (D) $\ln(M)$

Q.5 Which one of the following defines the absolute temperature of a system?

(A) $\left(\frac{\partial U}{\partial S}\right)_V$ (B) $\left(\frac{\partial A}{\partial S}\right)_V$ (C) $\left(\frac{\partial H}{\partial S}\right)_V$ (D) $\left(\frac{\partial G}{\partial S}\right)_V$

Q.6 Which of the following properties are characteristic of an ideal solution?

(i) $(\Delta_{mix}G)_{T,P}$ is negative

(ii) $(\Delta_{mix}S)_{T,P}$ is positive

(iii) $(\Delta_{mix}V)_{T,P}$ is positive

(iv) $(\Delta_{mix}H)_{T,P}$ is negative

(A) (i) and (iv) (B) (i) and (ii) (C) (i) and (iii) (D) (iii) and (iv)

Q.7 The expression for the equilibrium constant (K_{eq}) for the enzyme catalyzed reaction given below, is

$$E + S \underset{k_2}{\overset{k_1}{\rightleftharpoons}} ES \underset{k_4}{\overset{k_3}{\rightleftharpoons}} P + E$$

(A) $\frac{k_1k_3}{k_2k_4}$ (B) $\frac{k_1k_2}{k_3k_4}$ (C) $\frac{k_2k_3}{k_1k_4}$ (D) $\frac{k_1k_4}{k_2k_3}$

Q.8 Given the E^0 values for the following reaction sequence,

$$Mn^{6+} \xrightarrow{1.28\ V} Mn^{5+} \xrightarrow{2.9\ V} Mn^{4+} \xrightarrow{0.96\ V} Mn^{3+} \xrightarrow{1.5\ V} Mn^{2+}$$

the computed value of E^0 for $Mn^{6+} \rightarrow Mn^{2+}$ (in volts) is _____

Q.9 The absorption spectrum of $[Ti(H_2O)_6]^{3+}$ in solution comprises of a maximum with a shoulder. The reason for the shoulder is

(A) ligand-to-metal charge transfer (LMCT)
(B) metal-to-ligand charge transfer (MLCT)
(C) Jahn-Teller distortion
(D) nephelauxetic effect

Q.10 The ease of formation of the adduct, $NH_3 \cdot BX_3$ (where, X = F, Cl, Br) follows the order

(A) $BBr_3 < BCl_3 < BF_3$ (B) $BCl_3 < BF_3 < BBr_3$
(C) $BF_3 < BCl_3 < BBr_3$ (D) $BBr_3 < BF_3 < BCl_3$

Q.11 An efficient catalyst for hydrogenation of alkenes is $[Rh(PPh_3)_3Cl]$. However, $[Ir(PPh_3)_3Cl]$ does not catalyze this reaction, because

(A) PPh_3 binds stronger to Ir than to Rh
(B) Cl binds stronger to Ir than to Rh
(C) PPh_3 binds stronger to Rh than to Ir
(D) Cl binds stronger to Rh than to Ir

Q.12 Among the given pH values, the O_2 binding efficiency of hemoglobin is maximum at

(A) 6.8 (B) 7.0 (C) 7.2 (D) 7.4

Q.13 The intense red color of $[Fe(bpy)_3]^{2+}$ (bpy = 2,2′-bipyridine) is due to

(A) metal-to-ligand charge transfer (MLCT)
(B) ligand-to-metal charge transfer (LMCT)
(C) *d-d* transition
(D) inter-valence charge transfer (IVCT)

Q.14 The compound with planar geometry is

(A) $N(t\text{-}Bu)_3$ (B) NPh_3 (C) NF_3 (D) $N(SiH_3)_3$

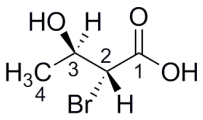
Q.15 The electrical conductivity of a metal

(A) increases with increasing temperature
(B) decreases with increasing temperature
(C) is independent of temperature
(D) shows oscillatory behaviour with temperature

Q.16 Which one of the following statements is **INCORRECT**?

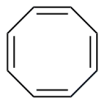
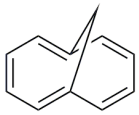
(A) Frenkel defect is a cation vacancy and a cation interstitial.
(B) Frenkel defect is an anion vacancy and a cation interstitial.
(C) Density of a solid remains unchanged in case of Frenkel defects.
(D) Density of a solid decreases in case of Schottky defects.

Q.17 The absolute configuration of *C*2 and *C*3 in the following compound is

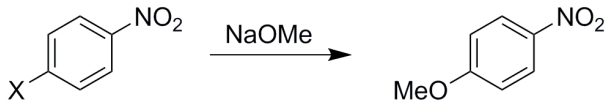


(A) 2*R*, 3*S* (B) 2*S*, 3*R* (C) 2*S*, 3*S* (D) 2*R*, 3*R*

Q.18 Among the following compounds, the one that is non-aromatic, is

(A)  (B)  (C)  (D) 

Q.19 The correct order of reactivity of *p*-halonitrobenzenes in the following reaction is



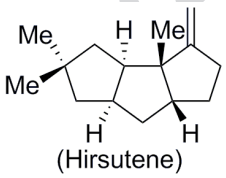
(X = F, Cl, Br, I)

(A) *p*-chloronitrobenzene > *p*-iodonitrobenzene > *p*-fluoronitrobenzene > *p*-bromonitrobenzene
(B) *p*-fluoronitrobenzene > *p*-chloronitrobenzene > *p*-bromonitrobenzene > *p*-iodonitrobenzene
(C) *p*-iodonitrobenzene > *p*-bromonitrobenzene > *p*-chloronitrobenzene > *p*-fluoronitrobenzene
(D) *p*-bromonitrobenzene > *p*-fluoronitrobenzene > *p*-iodonitrobenzene > *p*-chloronitrobenzene

Q.20 Tollen's test is **NEGATIVE** for

(A) mannose (B) maltose (C) glucose (D) sucrose

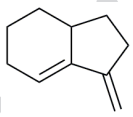
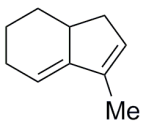
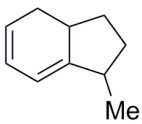
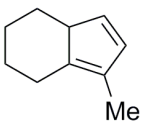
Q.21 The compound given below is a



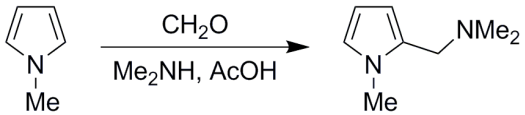
(Hirsutene)

(A) sesterterpene (B) monoterpene (C) sesquiterpene (D) triterpene

Q.22 Amongst the following, the compound that **DOES NOT** act as a diene in Diels-Alder reaction is

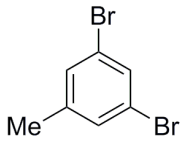
(A)  (B)  (C)  (D) 

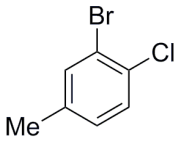
Q.23 The following conversion is an example of

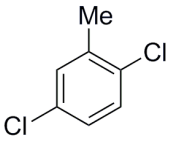


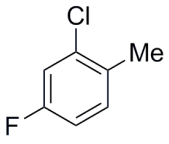
(A) Arndt-Eistert homologation (B) Mannich reaction
(C) Michael addition (D) Chichibabin amination reaction

Q.24 The mass spectrum of a dihalo compound shows peaks with relative intensities of 1:2:1 corresponding to M, M+2 and M+4 (M is the mass of the molecular ion), respectively. The compound is

(A) 

(B) 

(C) 

(D) 

Q.25 Reaction of benzaldehyde and *p*-methylbenzaldehyde under McMurry coupling conditions ($TiCl_3$ and $LiAlH_4$) gives a mixture of alkenes. The number of alkenes formed is _____

Q. 26 – Q. 55 carry two marks each.

Q.26 The difference in the ground state energies (kJ/mol) of an electron in one-dimensional boxes of lengths 0.2 nm and 2 nm is _____

Q.27 The mean ionic activity coefficient of 0.001 molal $ZnSO_4$ (aq) at 298 K according to the Debye-Hückel limiting law is (Debye-Hückel constant is 0.509 $molal^{-1/2}$) _____

Q.28 The process given below follows the Langmuir adsorption isotherm.

$$A_2\,(g) \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} 2\,A_{ads}$$

If θ denotes the surface coverage and P denotes the pressure, the slope of the plot of $1/\theta$ versus $1/\sqrt{P}$ is

(A) $1/(K_{eq})^2$ (B) $1/K_{eq}$ (C) $-1/K_{eq}$ (D) $1/(K_{eq})^{1/2}$

Q.29 For a gas phase unimolecular reaction at temperature 298 K, with a pre-exponential factor of $2.17 \times 10^{13}\ s^{-1}$, the entropy of activation (J K^{-1} mol^{-1}) is _____

Q.30 A liquid has vapor pressure of 2.02×10^3 N m^{-2} at 293 K and heat of vaporization of 41 kJ mol^{-1}. The boiling point of the liquid (in Kelvin) is _____

Q.31 The rotational partition function of a diatomic molecule with energy levels corresponding to $J = 0$ and 1, is (where, ε is a constant)

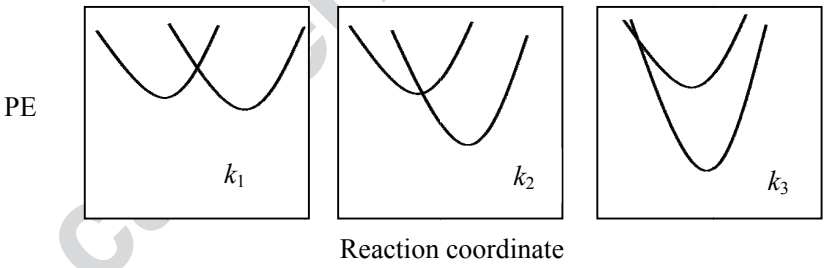
(A) $1+e^{-2\varepsilon}$ (B) $1+3e^{-2\varepsilon}$ (C) $1+ e^{-3\varepsilon}$ (D) $1+3e^{-3\varepsilon}$

Q.32 The internal energy of an ideal gas follows the equation $U = 3.5\ PV + k$, where k is a constant. The gas expands from an initial volume of 0.25 m^3 to a final volume of 0.86 m^3. If the initial pressure is 5 N m^{-2}, the change in internal energy (in Joules) is (given $PV^{1.3}$ = constant) _____

Q.33 The solubility product of AgBr(s) is 5×10^{-13} at 298 K. If the standard reduction potential of the half-cell, $E^0_{Ag|AgBr(s)|Br^-}$ is 0.07 V, the standard reduction potential, $E^0_{Ag^+|Ag}$ (in volts) is _____.

Q.34 One mole of a substance is heated from 300 K to 400 K at constant pressure. The C_P of the substance is given by, $C_P\ (\text{J K}^{-1}\text{mol}^{-1}) = 5 + 0.1\,T$. The change in entropy, in $\text{J K}^{-1}\text{mol}^{-1}$, of the substance is _____

Q.35 The potential energy (PE) versus reaction coordinate diagrams for electron transfer reactions with rate constants k_1, k_2 and k_3, are given below. The increasing order of the rate constants is



(A) $k_2 < k_3 < k_1$ (B) $k_2 < k_1 < k_3$ (C) $k_3 < k_2 < k_1$ (D) $k_3 < k_1 < k_2$

Q.36 The distance between two successive (110) planes in a simple cubic lattice with lattice parameter 'a' is

(A) $\sqrt{2}\,a$ (B) $\sqrt{3}\,a$ (C) $2\sqrt{2}\,a$ (D) $\frac{a}{\sqrt{2}}$

Q.37 The percent transmittance of 8×10^{-5} M solution of $KMnO_4$ is 39.8 when measured at 510 nm in a cell of path length of 1 cm. The absorbance and the molar extinction coefficient (in M^{-1} cm^{-1}) of this solution are, respectively,

(A) 0.30 and 4500 (B) 0.35 and 4800 (C) 0.4 and 5000 (D) 0.48 and 5200

Q.38 The value of '*g*' and the number of signals observed for the reference standard, diphenylpicrylhydrazyl (DPPH), in the solid state ESR spectrum are, respectively,

(A) 2.0036 and 1 (B) 2.0036 and 3 (C) 2.2416 and 1 (D) 2.2416 and 3

Q.39 Ammonolysis of S_2Cl_2 in an inert solvent gives

(A) S_2N_2 (B) $S_2N_2Cl_2$ (C) $S_2N_2H_4$ (D) S_4N_4

Q.40 The complexes $K_2[NiF_6]$ and $K_3[CoF_6]$ are

(A) both paramagnetic
(B) both diamagnetic
(C) paramagnetic and diamagnetic, respectively
(D) diamagnetic and paramagnetic, respectively

Q.41 The point group of IF_7 is

(A) D_{6h} (B) D_{5h} (C) C_{6v} (D) C_{5v}

Q.42 When one CO group is replaced by PPh_3 in $[Cr(CO)_6]$, which one of the following statements is **TRUE**?

(A) The Cr-C bond length increases and CO bond length decreases
(B) The Cr-C bond length decreases and CO bond length decreases
(C) The Cr-C bond length decreases and CO bond length increases
(D) The Cr-C bond length increases and CO bond length increases

Q.43 Identify X in the reaction, $[Pt(NH_3)_4]^{2+} + 2\ HCl \rightarrow X$

(A) *cis*-$[PtCl_2(NH_3)_2]$ (B) *trans*-$[PtCl_2(NH_3)_2]$

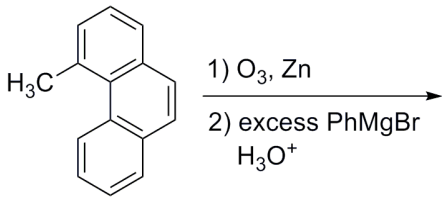
(C) $[PtCl(NH_3)_3]^+$ (D) $[PtCl_3(NH_3)]^-$

Q.44 Identify the function of hemocyanin and the metal responsible for it.

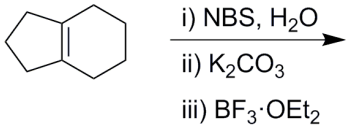
(A) O_2 transport and Fe
(B) O_2 transport and Cu
(C) electron transport and Fe
(D) electron transport and Cu

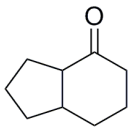
Q.45 The limiting current (in μA) from the reduction of 3×10^{-4} M Pb^{2+}, using a dropping mercury electrode (DME) with characteristics, $m = 3.0$ mg s^{-1} and $t = 3$s, is
(diffusion coefficient of $Pb^{2+} = 1.2 \times 10^{-5}$ cm^2 s^{-1}) _____

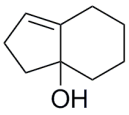
Q.46 The number of possible stereoisomers obtained in the following reaction is _____

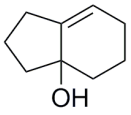


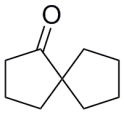
Q.47 The major product formed in the following reaction is



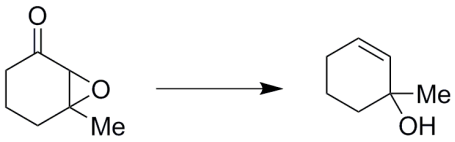
(A) 

(B) 

(C) 

(D) 

Q.48 The most suitable reagent(s) to effect the following transformation is



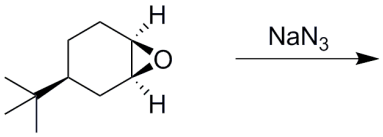
(A) N_2H_4, KOH, heat

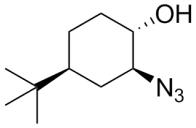
(B) $TsNHNH_2$, CF_3COOH

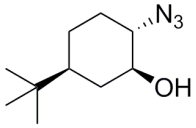
(C) $LiAlH_4$

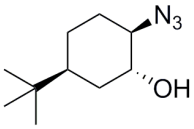
(D) Na, liq. NH_3

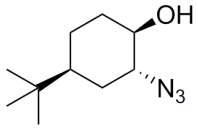
Q.49 The major product formed in the following reaction is



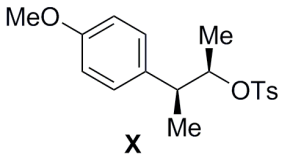
(A) 

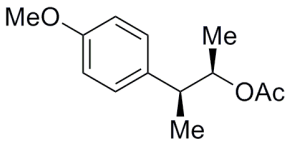
(B) 

(C) 

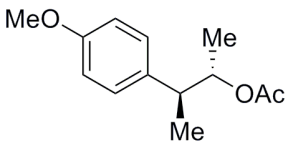
(D) 

Q.50 Solvolysis of the optically active compound **X** gives, mainly

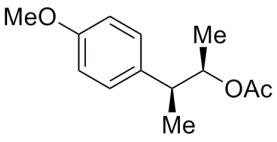


(A) 

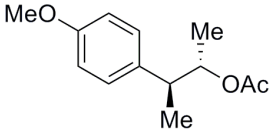
(optically active)

(B) 

(optically active)

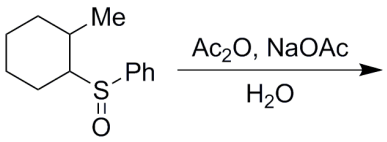
(C) 

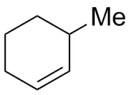
racemic
(optically inactive)

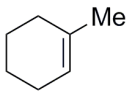
(D) 

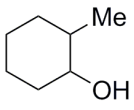
racemic
(optically inactive)

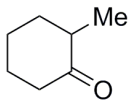
Q.51 The major product formed in the following reaction is



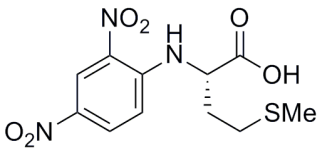
(A) 

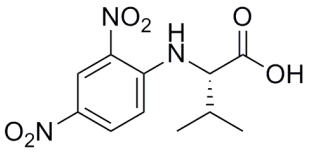
(B) 

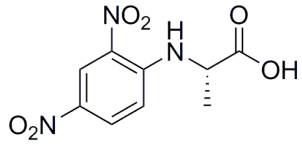
(C) 

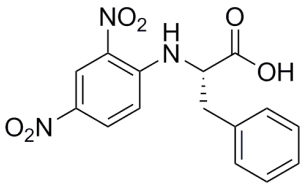
(D) 

Q.52 The tetrapeptide, Ala-Val-Phe-Met, on reaction with Sanger's reagent, followed by hydrolysis gives

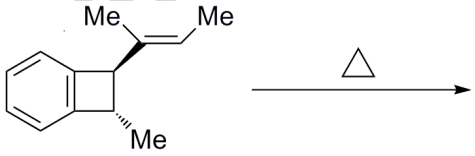
(A) 

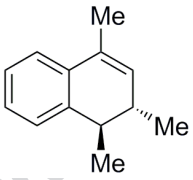
(B) 

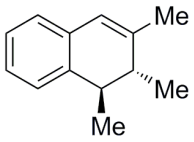
(C) 

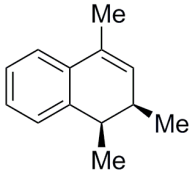
(D) 

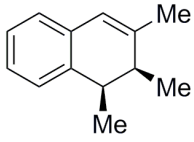
Q.53 The major product formed in the following reaction is



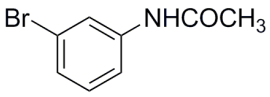
(A) 

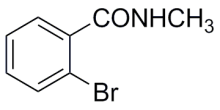
(B) 

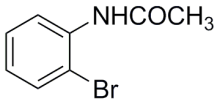
(C) 

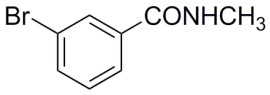
(D) 

Q.54 The Beckmann rearrangement of a bromoacetophenone oxime (C_8H_8BrNO) gives a major product having the following ^1H NMR (δ, ppm): 9.89 (s, 1H), 7.88 (s, 1H), 7.45 (d, 1H, J = 7.2 Hz), 7.17 (m, 1H), 7.12 (d, 1H, J = 7.0 Hz), 2.06 (s, 3H). The structure of the product is

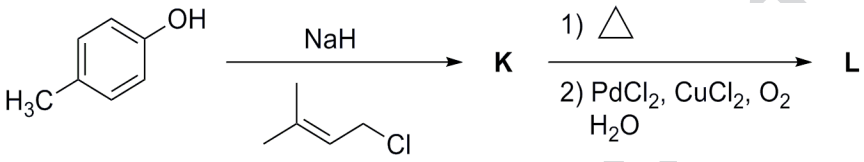
(A) 

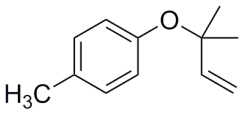
(B) 

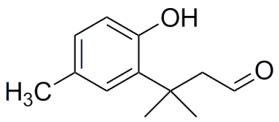
(C) 

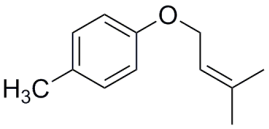
(D) 

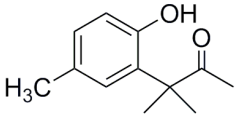
Q.55 The major products, **K** and **L** formed in the following reactions are

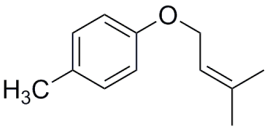


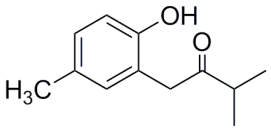
(A) **K** = 

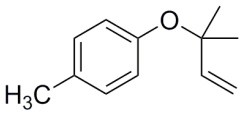
L = 

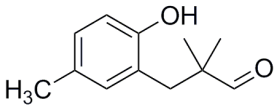
(B) **K** = 

L = 

(C) **K** = 

L = 

(D) **K** = 

L = 

END OF THE QUESTION PAPER