Suggested Worked Solution for 2022 JC1 YEE Paper 1 (9729/01)

| | 1 | С | 6 | D | 11 | Α | 16 | С | 21 | С | 26 | С | |
|---|---|----------|-------|-----------|-------|---------|------|----------|---------|-------------------|------|-----------|------|
| | 2 | В | 7 | Α | 12 | D | 17 | В | 22 | Α | 27 | С | |
| | 3 | D | 8 | С | 13 | Α | 18 | D | 23 | С | 28 | В | |
| | 4 | В | 9 | Α | 14 | В | 19 | D | 24 | С | 29 | В | |
| | 5 | D | 10 | Α | 15 | Α | 20 | Α | 25 | В | 30 | В | |
| | | | | | | | | | | | | | |
| Answe | Answer: C | | | | | | | | | | | | |
| The sha | apes | of the f | ive d | -orbitals | are s | shown b | elow | Of the f | ive, th | ne <u>first 4</u> | have | e four lo | bes. |
| $\int_{x} \frac{1}{d_{x}} \frac{1}{d_{y}} \frac{1}{d_{y}$ | | | | | | | | | | | | | |
| u _{yz} c | $d_{\chi\chi}$ orbital $d_{\chi\chi}$ orbital $d_{\chi\chi}$ orbital $d_{\chi\chi}^2 - y^2$ orbital d_z^2 orbital | | | | | | | | | | | | |

| | lobes between the axes lobes along the axes |
|---|---|
| 2 | Answer: B For W, since there is a sharp increase from the 7 th to 8 th IE, it implies that the 8 th electron of W is removed from the next inner quantum shell and hence, W has 7 valence electrons. Thus, <u>W is</u> <u>from Group 17</u> . Since W, X, Y and Z are consecutive elements, it implies that <u>X is from Group 18</u> , <u>Y is from</u> <u>Group 1 of the next Period</u> and <u>Z is from Group 2 of the next Period</u> . Hence, for the same nth IE, since the <u>IE generally increases across the Period and decreases</u> <u>down the Group</u> , <u>X has the highest 1st IE</u> . |
| 3 | Answer: D Interpret the two information as follow: X and Y form ionic compounds Na₂X and Na₂Y respectively. ⇒ X and Y form anion of charge 2–. Hence, they are <u>likely from Group 16</u> and has a <u>valence electronic configuration of ns² np⁴</u>. (Reject Option A and B) Element Y forms YF₆ molecules where X is not able to do so. ⇒ Y can expand octet but not X. Hence, <u>X is from Period 2</u> while <u>Y is from Period 3 onwards</u>. (Reject Option C) |
| 4 | Answer: B σ bond is formed from <u>head-on overlap</u> between orbitals (atomic orbitals and/or hybrid orbitals). (Reject Option C and D) s • • • s s • • • • p p • • • • p π bond is formed from <u>sideway overlap of p-orbitals</u>. (Reject Option A) |

1

| 5 | Answ | D | | | | | | |
|---|---|--|--|--|--|--|--|--|
| | | Molecular shape | Polarity | | | | | |
| | ×A | B is from Grp 13 (3 valence e ⁻). Around central B, there are <u>3 bp & 0 lp</u> . ⇒ Shape is <u>trigonal planar</u> . | Since there is <u>no lp</u> and the <u>surrounding atoms</u> <u>are identical</u> (all Cl), the dipole moment from each B–Cl bond cancelled out (<i>i.e.</i> <u>BCl₃ has</u> <u>no net dipole moment</u>). \Rightarrow <u>BCl₃ is non–polar</u> . | | | | | |
| | *B N is from Grp 15 (5 valence e^-).SAround central B, there are $3 \text{ bp } \& 1 \text{ lp}$. $e^ \Rightarrow$ Shape is trigonal pyramidal. e^- | | Since there is <u>1 lp</u> , the dipole moment from each N–C <i>l</i> bond are not cancelled out even though the surrounding atoms are the same (<i>i.e.</i> NC <i>l</i> ₃ has net dipole moment). \Rightarrow NC <i>l</i> ₃ is polar. | | | | | |
| | ×C | S is from Grp 16 (6 valence e^-). Around central S, there are <u>2 bp & 1 lp</u> . \Rightarrow Shape is <u>bent</u> . | Since there is <u>1 lp</u> , the dipole moment from each S=O bond are not cancelled out even though the surrounding atoms are the same (<i>i.e.</i> <u>SO₂ has net dipole moment</u>). \Rightarrow <u>SO₂ is polar</u> . | | | | | |
| | \checkmark DC is from Grp 14 (4 valence e ⁻). Around central C, there are $\underline{4 \text{ bp } \& 0 \text{ lp}}$. \Rightarrow Shape is <u>tetrahedral</u> . | | Since there is <u>1 lp</u> and the <u>surrounding atoms</u> <u>are different</u> , the dipole moments do not cancelled out (<i>i.e.</i> <u>CHCl_3 has net dipole</u> <u>moment</u>). \Rightarrow <u>CHCl_3 is polar</u> . | | | | | |
| 6 | Answer: D Both Al ₂ Cl ₆ and AlCl ₃ have simple molecular/covalent structures. (Reject Option A and B). Al ₂ Cl ₆ is formed from two AlCl ₃ monomer through <u>dative bond</u> formation. The <u>Cl</u> of one AlCl ₃ molecule has a lone pair (<i>i.e.</i> electron–rich) <u>to donate to</u> the empty p–orbital or <u>Al</u> of another AlCl ₃ molecule (<i>i.e.</i> electron–deficient) through dative bond formation. (Reject Option C | | | | | | | |
| 7 | Answer: A Option A is incorrect as compounds with giant covalent structure do not conduct electricity in any physical state due to the absence of mobile charge carrier. The only exception is graphite which conducts electricity in solid state and along the layer. | | | | | | | |
| 8 | Answer: C Both calcium and sodium have giant covalent structure. More energy is required to overcome the stronger metallic bonds between the mobile valence electrons and Ca²⁺ than that between the mobile valence electrons and Na⁺ since Ca has more mobile valence electrons available for metallic bonding and the charge density of Ca²⁺ is higher (due to higher ionic charge since both Ca²⁺ and Na⁺ have similar ionic radius). Hence, Ca has higher melting point than Na. Note: Option D is not the best answer since the statement is not specific in mentioning "mobile valence" electron. Thus, Option C is the most relevant. | | | | | | | |

| 9 | Answer: A (1 and 2 only) | | | | | | | | | | |
|----|---|--|--|--|--|--|--|--|--|--|--|
| | ✓1 Statement is true. | | | | | | | | | | |
| | At high pressure, volume of gas is smaller. Hence, the volume of gas <i>particle</i> becomes significant compared to the volume of gas. Also, at low temperature, the gas <i>particles</i> has less kinetic energy which is insufficient for them to overcome the intermolecular forces of attraction. Hence, gases deviate more from ideal gas behaviour at high pressure and low temperature. | | | | | | | | | | |
| | ✓2 Using pV = nRT = $\frac{mRT}{M_r}$, density (ρ) = $\frac{m}{V} = \frac{pM_r}{RT}$. | | | | | | | | | | |
| | Since p, M_r and R are constant, $\rho = k\left(\frac{1}{T}\right)$ (<i>i.e.</i> $\rho \propto \frac{1}{T}$). | | | | | | | | | | |
| | * 3 Using pV = nRT, when n, R and p are constant, $V = kT$ (<i>i.e.</i> $V \propto T$ (in K)) | | | | | | | | | | |
| | $V_2 = \frac{T_2}{T_1} \times V_1 \implies V_2 = \left(\frac{50 + 273}{25 + 273}\right) \times V_1 = \underline{1.08V_1} \text{ (not double!)}$ | | | | | | | | | | |
| 10 | Answer: A | | | | | | | | | | |
| | No. of particle = n(particles) × Avogadro's constant (<i>i.e.</i> no. of particles \propto n(particles)) | | | | | | | | | | |
| | n(HCO ₂ CH ₂ CH ₃) = 2.00 ÷ 74.0 = <u>0.0270 mol</u> | | | | | | | | | | |
| | $n(Br_2) = 4.00 \div 2(79.9) = 0.0250 \text{ mol}$ | | | | | | | | | | |
| | n(H ₂) at rtp = 550 ÷ 24000 = 0.0229 mol | | | | | | | | | | |
| | $n(H_2O) = (1.55 \times 10^{22}) \div (6.02 \times 10^{23}) = 0.0257 \text{ mol}$ | | | | | | | | | | |
| 11 | Answer: A | | | | | | | | | | |
| | $[R]: BrO_3^-(aq) + 6H^+(aq) + 6e^- \rightarrow Br^-(aq) + 3H_2O(l)$ | | | | | | | | | | |
| | $n(BrO_3^{-})$ used = $0.02 \times \frac{20.0}{1000} = 0.0004$ mol | | | | | | | | | | |
| | n(NH ₂ OH) used = $0.01 \times \frac{80.0}{1000} = 0.0008$ mol | | | | | | | | | | |
| | mole ratio BrO_3^- : e^- : NH_2OH | | | | | | | | | | |
| | since $1BrO_3^- \equiv 6e^-$ 0.0004 : 6(0.0004) | | | | | | | | | | |
| | since $n(e^{-})$ lost = $n(e^{-})$ gained 6(0.0004) : 0.0008 | | | | | | | | | | |
| | 3 : 1 | | | | | | | | | | |
| | ∴ Each N of NH₂OH lost 3 electrons. | | | | | | | | | | |
| | initial OS of N in $NH_2OH = -1$ | | | | | | | | | | |
| | final OS of N = $(-1) - 3(-1) = +2$ | | | | | | | | | | |
| | OS of N in NO = <u>+2</u> | | | | | | | | | | |
| | OS of N in NO ₂ = + 4 | | | | | | | | | | |
| | OS of N in $N_2O = +1$ | | | | | | | | | | |
| | OS of N in $NO_3^- = +5$ | | | | | | | | | | |
| | | | | | | | | | | | |

| 12 | Answer: D | | | | | | | | | | | |
|----|---|---|--|--|--|--|--|--|--|--|--|--|
| | *A The equation represents sum of 1 st and 2 nd EA of oxygen atom. | | | | | | | | | | | |
| | The equation for 2^{nd} EA of O should be O ⁻ (g) + e ⁻ \rightarrow O ²⁻ (g). | | | | | | | | | | | |
| | *B The equation represents $2 \times \Delta H_{neutralisation}$ since 2 moles of H ₂ O are formed. | | | | | | | | | | | |
| | ×C The equation represents 8 | *C The equation represents $8 \times \Delta H_{\text{formation}}$ of SO ₂ (a) since 8 moles of SO ₂ are formed | | | | | | | | | | |
| | | | | | | | | | | | | |
| 13 | Answer: A | | | | | | | | | | | |
| | $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(s)$ | $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(s) + 6O_2(g)$ | | | | | | | | | | |
| | 6(-355) 6(+90) (-710) 6(0) | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | Using formula, | | | | | | | | | | | |
| | $\Delta H_{\rm r} = \Sigma m \Delta H_{\rm f}({\rm products}) - \Sigma n \Delta H_{\rm f}$ | (reactants) | | | | | | | | | | |
| | = [(-710) + 0] - [6(-355) + | 6(+90)] = <u>+880 kJ mol⁻¹</u> > 0 (| Option C and D rejected.) | | | | | | | | | |
| | | | | | | | | | | | | |
| | $\Delta S^{\circ} < 0$ as there is a decreases from 6 to 0 | ase in disorderliness of th | e system since the number of liquid | | | | | | | | | |
| | | | | | | | | | | | | |
| | Note: The number of gaseous | particles remains unchanged | at 6 mol after the reaction. Hence, the | | | | | | | | | |
| | impact of gaseous partic | e on the entropy of the system | n is the less significant factor. | | | | | | | | | |
| | | | | | | | | | | | | |
| 14 | Answer: B (2 only) | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | ×1 | √2 | ×3 | | | | | | | | | |
| | $\Delta G = \Delta H - T \Delta S$ | $\Delta \mathbf{G} = \Delta \mathbf{H} - \mathbf{T} \Delta \mathbf{S}$ | $\Delta \boldsymbol{G} = \Delta \boldsymbol{H} - T \ \Delta \boldsymbol{S}$ | | | | | | | | | |
| | + ve -ve +ve -ve +ve -ve +ve -ve +ve +ve +ve +ve +ve +ve +ve +ve +ve + | | | | | | | | | | | |
| | +veve | -ve_+ve | -ve <u>ve</u> | | | | | | | | | |
| | +veve +ve | | | | | | | | | | | |
| | +ve $-ve$ +ve Since $\Delta G > 0$ at all T, the | $-ve +ve -ve$ Since $\Delta G < 0$ at all T, the reaction is spontaneous | -ve -ve + ve + ve At <u>low enough T</u> , $\Delta G < 0$ since | | | | | | | | | |
| | +ve $-ve$ +ve Since $\Delta G > 0$ at all T, the reaction is <u>not spontaneous</u> at all T. | $-ve +ve -ve$ Since $\Delta G < 0$ at all T, the reaction is spontaneous at all T. | $-ve \underbrace{-ve}_{+ve}$ At <u>low enough T</u> , <u>$\Delta G < 0$</u> since $\underline{ \Delta H > -T\Delta S }$. Hence, the reaction is spontaneous at low enough T . | | | | | | | | | |
| | +ve $-ve_{+ve}$ Since $\Delta G > 0$ at all T, the reaction is <u>not spontaneous</u> <u>at all T</u> . | -ve <u>+ve</u> -ve Since <u>ΔG < 0 at all T</u> , the reaction is <u>spontaneous</u> <u>at all T</u> . | $-ve \underbrace{-ve}_{+ve}$ At <u>low enough T</u> , $\Delta G < 0$ since $ \Delta H > -T\Delta S $. Hence, the reaction is <u>spontaneous at low enough T</u> . | | | | | | | | | |
| 15 | $\frac{+ ve}{+ ve} = \frac{-ve}{+ ve}$ Since $\Delta G > 0$ at all T, the reaction is <u>not spontaneous</u> at all T. | -ve +ve -ve Since $\Delta G < 0$ at all T, the reaction is <u>spontaneous</u> <u>at all T</u> . | -ve -ve + ve + ve At <u>low enough T</u> , <u>$\Delta G < 0$ since</u> [ΔH] > [$-T\Delta S$]. Hence, the reaction is <u>spontaneous at low enough T</u> . | | | | | | | | | |
| 15 | $\frac{+\text{ve} - \text{ve}}{+\text{ve}}$ Since $\Delta G > 0$ at all T, the reaction is <u>not spontaneous</u> <u>at all T</u> . Answer: A (1 and 2 only) | $-Ve +Ve -Ve$ Since $\Delta G < 0$ at all T, the reaction is spontaneous at all T. | $-ve \underbrace{-ve}_{+ve}$ At <u>low enough T</u> , <u>$\Delta G < 0$</u> since [ΔH] > [$-T\Delta S$]. Hence, the reaction is <u>spontaneous at low enough T</u> . | | | | | | | | | |
| 15 | +ve $-ve_{+ve}$ Since $\Delta G > 0$ at all T, the reaction is <u>not spontaneous</u> <u>at all T</u> . Answer: A (1 and 2 only) [VO ₂ ⁺] / mol dm ⁻³ | -ve <u>+ve</u> Since <u>ΔG < 0 at all T</u> , the reaction is <u>spontaneous</u> <u>at all T</u> . | $-ve -ve + ve$ At <u>low enough T</u> , $\Delta G < 0$ since $ \Delta H > -T\Delta S $. Hence, the reaction is <u>spontaneous at low enough T</u> . | | | | | | | | | |
| 15 | $\frac{+\text{ve} - \text{ve}}{+\text{ve}}$ Since $\underline{AG} > 0$ at all T, the reaction is <u>not spontaneous</u> at all T. Answer: A (1 and 2 only) [VO ₂ ⁺] / mol dm ⁻³ 0.2 | $\frac{-\text{Ve}}{-\text{Ve}} + \text{Ve}}{-\text{Ve}}$ Since $\Delta G < 0$ at all T, the reaction is <u>spontaneous</u> at all T. | $-Ve -Ve + Ve + Ve$ At <u>low enough T</u> , $\Delta G < 0$ since $ \Delta H > -T\Delta S $. Hence, the reaction is spontaneous at low enough T . | | | | | | | | | |
| 15 | $\frac{+\text{ve} -\text{ve}}{+\text{ve}}$ Since $\Delta G > 0$ at all T, the reaction is <u>not spontaneous</u> at all T. Answer: A (1 and 2 only) [VO ₂ ⁺] / mol dm ⁻³ 0.2 | $\frac{-\text{Ve}}{-\text{Ve}} + \text{Ve}}{-\text{Ve}}$ Since $\Delta G < 0$ at all T, the reaction is <u>spontaneous</u> at all T. | $-Ve -Ve + Ve + Ve$ At <u>low enough T</u> , $\Delta G < 0$ since $ \Delta H > -T\Delta S $. Hence, the reaction is <u>spontaneous at low enough T</u> . | | | | | | | | | |
| 15 | $\frac{+\text{ve} -\text{ve}}{+\text{ve}}$ Since $\Delta G > 0$ at all T, the reaction is <u>not spontaneous</u> at all T. Answer: A (1 and 2 only) [VO ₂ ⁺] / mol dm ⁻³ 0.2 | $-ve +ve -ve$ Since $\Delta G < 0$ at all T, the reaction is spontaneous at all T. | -Ve -Ve + Ve + Ve At <u>low enough T</u> , <u>AG < 0</u> since <u> AH > -TAS </u> . Hence, the reaction is <u>spontaneous at low enough T</u> . | | | | | | | | | |
| 15 | $+ve -ve +ve$ Since $\Delta G > 0$ at all T, the reaction is not spontaneous at all T. Answer: A (1 and 2 only) $[VO_2^+] / mol dm^{-3}$ 0.2 0.15 | $\frac{-\text{Ve}}{-\text{Ve}} + \text{Ve}}{-\text{Ve}}$ Since $\Delta G < 0$ at all T, the reaction is <u>spontaneous</u> at all T. | $-Ve -Ve + Ve + Ve$ At <u>low enough T</u> , $\Delta G < 0$ since $ \Delta H > -T\Delta S $. Hence, the reaction is <u>spontaneous at low enough T</u> . | | | | | | | | | |
| 15 | +ve -ve +ve Since $\Delta G > 0$ at all T, the reaction is <u>not spontaneous</u> <u>at all T</u> . Answer: A (1 and 2 only) [VO ₂ ⁺] / mol dm ⁻³ 0.2 0.15 | $\frac{-\text{Ve}}{-\text{Ve}}$ Since $\Delta G < 0$ at all T, the reaction is <u>spontaneous</u> at all T. | $-ve -ve +ve$ At <u>low enough T</u> , $\Delta G < 0$ since $ \Delta H > -T\Delta S $. Hence, the reaction is <u>spontaneous at low enough T</u> . | | | | | | | | | |
| 15 | $+ve -ve +ve$ Since $\Delta G > 0$ at all T, the reaction is not spontaneous at all T. Answer: A (1 and 2 only) $[VO_2^+] / mol dm^{-3}$ 0.2 0.15 | $\frac{-\text{Ve}}{-\text{Ve}} + \text{Ve}}{-\text{Ve}}$ Since $\Delta G < 0$ at all T, the reaction is <u>spontaneous</u> at all T. | $-Ve -Ve + Ve + Ve$ At <u>low enough T</u> , <u>$\Delta G < 0$</u> since <u>$\Delta H > -T\Delta S$</u> . Hence, the reaction is <u>spontaneous at low enough T</u> . | | | | | | | | | |
| 15 | $+ve -ve +ve$ Since $\Delta G > 0$ at all T, the reaction is not spontaneous at all T. Answer: A (1 and 2 only) [VO ₂ ⁺] / mol dm ⁻³ 0.2 0.15 0.1 | $\frac{-\text{Ve}}{-\text{Ve}}$ Since $\Delta G < 0$ at all T, the reaction is <u>spontaneous</u> at all T. | $-ve -ve +ve$ At <u>low enough T</u> , <u>$\Delta G < 0$ since</u> [ΔH] > [$-T\Delta S$]. Hence, the reaction is <u>spontaneous at low enough T</u> . | | | | | | | | | |
| 15 | $+ve -ve +ve$ Since $\Delta G > 0$ at all T, the reaction is not spontaneous at all T. Answer: A (1 and 2 only) [VO ₂ ⁺] / mol dm ⁻³ 0.2 0.15 0.1 | $\frac{-\text{Ve}}{-\text{Ve}} + \text{Ve}}{-\text{Ve}}$ Since $\Delta G < 0$ at all T, the reaction is <u>spontaneous</u> at all T. | -Ve -Ve + Ve At <u>low enough T</u> , <u>AG < 0</u> since <u>[AH] > [-TAS]</u> . Hence, the reaction is <u>spontaneous at low enough T</u> . | | | | | | | | | |
| 15 | $+ve -ve +ve$ Since $\Delta G > 0$ at all T, the reaction is not spontaneous at all T. Answer: A (1 and 2 only) [VO ₂ +] / mol dm ⁻³ 0.2 0.15 0.1 | $\frac{-\text{Ve}}{-\text{Ve}}$ Since $\Delta G < 0$ at all T, the reaction is <u>spontaneous</u> at all T. | -Ve -Ve + Ve At <u>low enough T</u> , <u>AG < 0</u> since [<u>AH</u>] > [-T <u>AS</u>]. Hence, the reaction is <u>spontaneous at low enough T</u> . | | | | | | | | | |
| 15 | $+ve -ve +ve$ Since $\Delta G > 0$ at all T, the reaction is not spontaneous at all T. Answer: A (1 and 2 only) $[VO_2^+] / mol dm^{-3}$ 0.2 0.15 0.1 0.05 | $\frac{-\text{Ve}}{-\text{Ve}} + \text{Ve}}{-\text{Ve}}$ Since $\Delta G < 0$ at all T, the reaction is <u>spontaneous</u> at all T. | -ve -ve +ve At <u>low enough T</u> , <u>AG < 0</u> since <u> AH > -TAS </u> . Hence, the reaction is <u>spontaneous at low enough T</u> . | | | | | | | | | |
| 15 | $+ve -ve +ve$ Since $\Delta G > 0$ at all T, the reaction is not spontaneous at all T. Answer: A (1 and 2 only) [VO ₂ ⁺] / mol dm ⁻³ 0.2 0.15 0.1 0.05 t _{1/2,1} = 32 min t _{1/2,1} = 30 | -Ve +Ve -Ve Since $\Delta G < 0$ at all T, the reaction is <u>spontaneous</u> at all T. | -Ve -Ve + Ve At <u>low enough T</u> , <u>AG < 0</u> since [<u>AH</u>] > [-T <u>AS</u>]. Hence, the reaction is <u>spontaneous at low enough T</u> . [As ₂ O ₃] = 0.05 mol dm ⁻³ | | | | | | | | | |
| 15 | $+ve -ve +ve$ Since $\Delta G > 0$ at all T, the reaction is not spontaneous at all T. Answer: A (1 and 2 only) $[VO_2^+] / \text{ mol dm}^{-3}$ 0.2 0.15 0.15 0.1 $volume{1}{} volume{1}{} volume$ | -Ve +Ve -Ve Since $\Delta G < 0$ at all T, the reaction is <u>spontaneous</u> at all T. | $-Ve -Ve + Ve$ At <u>low enough T</u> , <u>AG < 0</u> since <u> AH > -TAS </u> . Hence, the reaction is <u>spontaneous at low enough T</u> . $[As_2O_3] = 0.05 \text{ mol dm}^{-3}$ $[As_2O_3] = 0.10 \text{ mol dm}^{-3}$ | | | | | | | | | |
| 15 | $+ Ve - Ve + Ve$ Since $\Delta G > 0$ at all T, the reaction is not spontaneous at all T. Answer: A (1 and 2 only) $[VO_2^+] / \text{mol dm}^{-3}$ 0.2 0.15 0.1 0.15 0.1 0.05 $t_{1/2,1} = 32 \min t_{1/2,1} = 30$ 0 0 0 0 0 0 0 0 0 0 0 0 0 | $\frac{-\text{Ve}}{-\text{Ve}} + \text{Ve}}{-\text{Ve}}$ Since $\Delta G < 0$ at all T, the reaction is <u>spontaneous</u> at all T. | -Ve - Ve + Ve At <u>low enough T</u> , <u>AG < 0</u> since [<u>AH</u>] > [-T <u>AS</u>]. Hence, the reaction is <u>spontaneous at low enough T</u> . [As ₂ O ₃] = 0.05 mol dm ⁻³ [As ₂ O ₃] = 0.10 mol dm ⁻³ + time / min 120 | | | | | | | | | |
| 15 | $+ ve -ve + ve$ Since $\Delta G > 0$ at all T, the reaction is not spontaneous at all T. Answer: A (1 and 2 only) [VO ₂ ⁺] / mol dm ⁻³ 0.2 0.15 0.15 0.1 0.05 $t_{1/2,1} = 32 \min t_{1/2,1} = 30$ 0 0 0 0 0 0 0 0 0 0 0 0 0 | $\frac{-\text{Ve}}{-\text{Ve}} + \text{Ve}}{-\text{Ve}}$ Since $\Delta G < 0$ at all T, the reaction is <u>spontaneous</u> at all T. | $\frac{-\sqrt{e} - \sqrt{e}}{+\sqrt{e}}$ At <u>low enough T</u> , <u>AG < 0</u> since [<u>AH</u>] > [-T <u>AS</u>]. Hence, the reaction is <u>spontaneous at low enough T</u> . [As ₂ O ₃] = 0.05 mol dm ⁻³ [As ₂ O ₃] = 0.10 mol dm ⁻³ \rightarrow time / min 120 | | | | | | | | | |

| | √ 1 | Using the graph, where $[As_2O_3] = 0.10$ mol dm ⁻³ , (see construction lines in blue) | | | | | | | |
|----|--------------------|--|--|--|--|--|--|--|--|
| | | average $t_{1/2} = \frac{32+30}{2} = 31 \text{ min}$ | | | | | | | |
| | | 2 Since the two holf, lives are enprovimetally constant, the order of reaction wrt [VO t] is one | | | | | | | |
| | 12 | Since the two half-lives are approximately constant, the order of reaction wit $[vO_2]$ is one. | | | | | | | |
| | · - | 0 - 0.20 | | | | | | | |
| | | initial rate when [As ₂ O ₃] is $0.05 = \left \frac{0 - 0.20}{88 - 0} \right = \frac{0.00227 \text{ mol dm}^{-3} \text{ min}^{-1}}{1000000000000000000000000000000000$ | | | | | | | |
| | | initial rate when [As ₂ O ₃] is 0.10 = $\left \frac{0 - 0.20}{44 - 0}\right = \frac{0.00455 \text{ mol dm}^{-3} \text{ min}^{-1}}{44 - 0}$ | | | | | | | |
| | | Hence, when [As ₂ O ₃] is doubled, the initial rate is also doubled. Thus, the <u>order of reaction</u> wrt [As ₂ O ₃] is one. | | | | | | | |
| | ¥3 | <u>H₂SO₄ is not a catalyst</u> since H ⁺ is reacted and not regenerated, according to the equation given. The order of reaction wrt [H ⁺] can be determined by repeating the experiment with different [H ₂ SO ₄] while keeping [VO ₂ ⁺] at 0.2 mol dm ⁻³ and [As ₂ O ₃] at 0.10 mol dm ⁻³ . Then, determine the initial rate. | | | | | | | |
| 16 | Ans | wer: C | | | | | | | |
| | Sinc | be the reaction is an overall 1 st order reaction, the formula $t_{\rm esc} = \frac{\ln 2}{2}$ | | | | | | | |
| | Onic | we the reaction is an overall 1 order reaction, the formula $t_{1/2} = \frac{1}{k}$ applies. | | | | | | | |
| | t _{1/2} c | of XY = $\frac{\ln 2}{0.2}$ = 3.47 s | | | | | | | |
| | Usir | Jsing the formula $\frac{\text{final conc.}}{\text{initial conc}} = \left(\frac{1}{2}\right)^n$ where n is the no. of half–lives passed, | | | | | | | |
| | 1 | $(1)^{n}$ | | | | | | | |
| | $\frac{-}{8} =$ | $\left(\frac{1}{2}\right) \Rightarrow n = 3$ | | | | | | | |
| | time | taken = 3 × 3.47 = <u>10.4 s</u> | | | | | | | |
| | | | | | | | | | |
| 17 | Ans | wer: B | | | | | | | |
| | Sinc pea | te the reaction occurs via a <u>two-step mechanism</u> , the energy profile diagram <u>should have two</u> ks. (Reject Option A) | | | | | | | |
| | Sinc | the reaction is exothermic, the energy level of products must be lower than that of reactants. | | | | | | | |
| | | (Reject Option D) | | | | | | | |
| | Sinc | Since step 1 is the slow step, step 1 has the largest <i>E</i> a (not the highest peak!). (Reject Option C) | | | | | | | |
| | Note | \underline{e} : For Option C, the 2 nd step has the largest E_a ! | | | | | | | |
| 18 | Ans | wer: D | | | | | | | |
| | Sinc | te the reaction is auto-catalysed, the rate of reaction will increase then decrease. | | | | | | | |
| 19 | Ans | wer: D (3 only) | | | | | | | |
| | Fror | n the graph, when [substrate] = x (<i>i.e.</i> high [substrate]), the rate remains constant. | | | | | | | |
| | This incre | is because all the active sites of enzymes are occupied and hence, the rate will not ease further with increasing [substrate]. | | | | | | | |
| | | | | | | | | | |

| 20 | Answer: A | | | | | | | | | |
|----|--|---------------------------------|-------------------------|---------------------|------------------------------------|-----------------------------------|--------------------|----------------------------|-------------------------------|--|
| | | CH ₄ (g) | + | 2H ₂ (g) | \rightleftharpoons | CS ₂ (g) | + | 4H ₂ | | |
| | initial / mol dm ⁻³ | $\frac{1}{0.5} = 2$ | | $\frac{2}{0.5} = 4$ | | $\frac{1}{0.5} = 2$ | | $\frac{2}{0.5} = 4$ | | |
| | change | -0.88 | | -2(0.88) | | +0.88 | | +4(0.88) | | |
| | eqm / mol dm ⁻³ | 1.12 | | 2.24 | | 2.88 | | 7.52 | | |
| | $K_{c} = \frac{[CS_{2}][H_{2}]^{4}}{[CH_{4}][H_{2}S]^{2}} =$ | = (2.88)(7.52 (1.12)(2.24 | $(2)^4$ = | <u>1640</u> | | | | | | |
| 21 | Answer: C | | | | | | | | | |
| | From the graph, a | at t, n(SO ₂) (| decre | ases while | e n(SO | a) increase | s. Th | is implies t | hat <u>position of</u> | |
| | equilibrium shiited i ≭∆ When catalys | <u>igni</u> . It is added ir | noe d | oes not sl | hift sind | e the rate | of bo | oth forward | and backward | |
| | reaction increa | ase by the sa | me ex | ktent. | | | | | | |
| | *B When SO ₂ is | added, the g | raph | will show a | a <u>sharp</u> | increase in | <u>n n(SC</u> | D ₂) at time t | and poe shifts | |
| | <u>right</u> so as to <u>react away SOME of the SO₂ added</u> . | | | | | | | | | |
| | produce some heat to increase the temperature. | | | | | | | | | |
| | *D When volume of vessel was increased, the pressure of all gases decreases at that instant | | | | | | | | | |
| | pressure. | ne <u>poe snifts</u> | lett | to increase | e the h | umper of | gas p | articles so | as to increase | |
| | | | | | | | | | | |
| 22 | Answer: A | | | | | | | | | |
| | % ndt | | | | Fron | n the gra | ph, <u>%</u> | 5 product | at equilibrium | |
| | at eqm | | | | decr | <u>eases as p</u> | inensui | re increases | <u>8</u> . | |
| | | | ~ / - | | \Rightarrow 7 \rightarrow V | o product ↓ Vhen press | ∕ implie suro ↑ | it favours | the side with | |
| | | | (1) | + 10) °C | <u>le</u> | ess gas pai | rticles | so as to rec | luce pressure. | |
| | | | T (| °C | .:. <u>L</u> | HS of th | e eq | uilibrium e | equation has | |
| | p less gas particles. (Reject Option B, C, D) | | | | | | | | | |
| | | | | | | | | | | |
| | % pdt | | | | From | n the gra | ph, <u>%</u> | <u>product</u> | at equilibrium | |
| | at eqm | | | | <u>Incre</u> → % | <u>eases as te</u> 6 product 1 | impera | ature increas | <u>ses</u> . shifted right | |
| | | | ∕_/т | . 10\ °C | $\Rightarrow V$ | Vhen tem | perati | ure ↑. it | favours the | |
| | | | 、'1 | + 10) *C | <u>e</u> | ndothermi | c react | <u>ion</u> to abso | rb some heat. | |
| | | | T | °C | ∴ <u>F</u> | orward re | actior | <u>is endoth</u> | ermic. (Reject | |
| | | | | → p | C | ption C an | ia D) | | | |
| | | | | | | | | | | |



| 27 | Answer: C (1 and 2 only) | | | | | | | | |
|----|---|---|----------------------------------|---|--------------------|--|--|--|--|
| | *1 Standard condition for gas is <u>1 bar (10⁵ Pa) and 298 K</u> . | | | | | | | | |
| | *2 Standard condition for aqueous solution is 1 mol dm ⁻³ . For SHE, <u>1 mol dm⁻³ H⁺(aq) is required</u> . Since $2H^+ \equiv 1H_2SO_4$, [H ⁺] in the given setup is 2.0 mol dm ⁻³ instead of the required 1 mol dm ⁻³ . | | | | | | | | |
| | ✓3 Platinised F divided Pt p | ✓3 Platinised Pt is used as electrode. "Platinised" means that the electrode is coated with finely divided Pt powder. | | | | | | | |
| 28 | Answer: B (2 and 3 only) | | | | | | | | |
| | $Cl_2 + 2e^- \rightleftharpoons 20$ | $Cl_2 + 2e^- \rightleftharpoons 2Cl^- + 1.36 \text{ V} \text{ (more +ve } \Rightarrow [R])$ | | | | | | | |
| | Fe ³⁺ + e⁻ \ Fe | e ²⁺ +0.77 V (more | $-ve \Rightarrow [O]$) | | | | | | |
| | | | | | | | | | |
| | ×1 Since ther | e is no metal in both r | nalf-equations, <u>both x</u> | <u>k and Y should be plating</u> | <u>um metal</u> . | | | | |
| | \checkmark 3 Based on | the F^{\ominus} value Fe ³⁺ / | Fe ²⁺ undergoes oxida | ne gas need not be dry. ation while Cl ₂ /Cl ⁻ under | noes reduction | | | | |
| | Hence, <u>Y</u> | is anode and X is cat | hode. Thus, the electro | ons flow from Y to X throu | igh the external | | | | |
| | circuit. | | | | | | | | |
| 20 | Anowory P | | | | | | | | |
| 29 | For galvanic ce | ell, recall that positive | electrode is cathod | e (<i>i.e.</i> reduction) and neg | ative electrode | | | | |
| | is anode (i.e. o | oxidation). | | <u>e</u> (<i>i.e.</i> reduction) and <u>neg</u> | | | | | |
| | Also, reducing | power of metal refers | to the ability of the m | etal to reduce other specie | es while itself is | | | | |
| | oxidised (<i>i.e.</i> <u>m</u> | iore negative <i>E</i> , <u>nigr</u> | her the reducing pow | <u>'er</u>). | | | | | |
| | | positive electrode | negative electrode | | | | | | |
| | | (cathode, [R]) | (anode, [O]) | Reducing power order | | | | | |
| | | Р | Mg | Mg > P | | | | | |
| | | Mg | R | R > Mg | | | | | |
| | Hence, the red | ucing power of <u>R > M</u> | <u>g > P</u> . | | | | | | |
| | | | | | | | | | |
| 30 | Answer: B | | | | | | | | |
| | | | wrt SHE: F(AqCI/Aq) = 22 | | | | | | |
| | E(E) | wrt SHE: $p^{2+}/F_{O} = 0.44 V$ | | | | | | | |
| | ∠(I (◄── | • |) | | | | | | |
| | | | | | | | | | |
| | –0.44 (Fe ²⁺ /F | v 0.0 Fe) (SH | JV (AgCl/Ag) HE) | | | | | | |
| | │ ` ← | $\frac{1}{2}$ | , | | | | | | |
| | | $E(Fe^{2+}/Fe) = -0.$ | 64 V | | | | | | |
| | Based on the d | liagram above, it can | be calculated that E(A | gC∥Ag) wrt SHE is +0.20 | V. | | | | |
| | | | | | | | | | |