නව නිර්දේශය /புதிய பாடத்திட்டம்/New Syllabus

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2020
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2020
General Certificate of Education (Adv. Level) Examination, 2020

රසායන විද්‍යාව	II
இரசாயனவியல்	II
Chemistry	II

02 E II

* Universal gas constant $R = 8.314\ J\ K^{-1}\ mol^{-1}$
* Avogadro constant $N_A = 6.022 \times 10^{23}\ mol^{-1}$

PART B — ESSAY

Answer two questions only. (Each question carries **150** *marks.)*

5. (*a*) A compound $XY_2Z_2(g)$ undergoes dissociation when heated to temperatures above 300 K as given below.

$$XY_2Z_2(g) \overset{\Delta}{\rightleftharpoons} XY_2(g) + Z_2(g)$$

A sample of 7.5 g of $XY_2Z_2(g)$ was placed in an evacuated 1.00 dm^3 rigid-closed container and the temperature was raised to 480 K.
Molar mass of $XY_2Z_2(g)$ is 150 g mol^{-1}. Use the approximate value of 4000 J mol^{-1} for RT at 480 K. Assume ideal gas behaviour for all gases.

(i) Calculate the number of moles of $XY_2Z_2(g)$ in the container before dissociation.

(ii) When the above system reaches equilibrium at 480 K, the total number of moles in the container was found to be 7.5×10^{-2} mol. Calculate the number of moles of $XY_2Z_2(g)$, $XY_2(g)$ and $Z_2(g)$ in the equilibrium mixture at 480 K.

(iii) Calculate the equilibrium constant K_c for the above reaction at 480 K.

(iv) Calculate K_p for the equilibrium at 480 K. **(75 *marks*)**

(*b*) For the reaction $XY_2Z_2(g) \rightarrow XY_2(g) + Z_2(g)$ described in (a), Gibbs free energies (G) at 480 K for $XY_2Z_2(g)$, $XY_2(g)$ and $Z_2(g)$ are -60 kJ mol^{-1}, -76 kJ mol^{-1} and -30 kJ mol^{-1}, respectively.

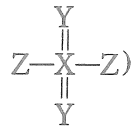
(i) Calculate ΔG (in kJ mol^{-1}) for the reaction at 480 K.

(ii) The magnitude of ΔS of the above reaction is 150 J K^{-1} mol^{-1} at 480 K. Calculate ΔH for the reaction at 480 K by using the appropriate sign (– or +) of ΔS.

(iii) By using the sign (– or +) of ΔH obtained in (ii), explain whether this reaction is exothermic or endothermic.

(iv) Deduce the enthalpy difference for the formation of $XY_2Z_2(g)$ from $XY_2(g)$ and $Z_2(g)$ at 480 K.

(v) If the bond enthalpy of the X–Z bond in $XY_2Z_2(g)$ is +250 kJ mol^{-1}, calculate the bond enthalpy of the Z–Z bond.

(Assume that $XY_2Z_2(g)$ has the structure )

(vi) If liquid XY_2Z_2 is used instead of gaseous XY_2Z_2, giving reasons, explain whether the value of ΔH obtained for the reaction $XY_2Z_2(l) \rightarrow XY_2(g) + Z_2(g)$ is equal to, or higher or lower than ΔH obtained in (ii).

(75 *marks*)

[*see page ten*

6. (*a*) Consider the reaction given below occurring in a closed container at a given temperature *T*.

$$2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$$

(i) Write **three** expressions for the rate of reaction relevant to each of the compounds appearing in the reaction.

(ii) This reaction was carried out at temperature *T* with an initial concentration of 0.10 mol dm^{-3} of $N_2O_5(g)$. It was found that 40% of the initial amount was decomposed after a period of 400 s.

I. Calculate the average rate of decomposition of $N_2O_5(g)$ in this time interval.

II. Calculate average rates of formation of $NO_2(g)$ and $O_2(g)$.

(iii) In another experiment, initial rates were measured for this reaction at 300 K and the results are given below.

$[N_2O_5(g)]$ / mol dm^{-3}	0.01	0.02	0.03
Initial rate / mol dm^{-3} s^{-1}	6.930×10^{-5}	1.386×10^{-4}	2.079×10^{-4}

Derive the rate law for the reaction at 300 K.

(iv) Another experiment was carried out at 300 K with an initial concentration of 0.64 mol dm^{-3} of $N_2O_5(g)$. It was found that the concentration of $N_2O_5(g)$ which remained after a period of 500 s was 2.0×10^{-2} mol dm^{-3}.

I. Calculate the half-life ($t_{1/2}$) of the reaction at 300 K.

II. Calculate the rate constant of the reaction at 300 K.

(v) This reaction proceeds through a mechanism involving the following elementary steps.

Step 1 : $N_2O_5(g) \rightleftharpoons NO_3(g) + NO_2(g)$: Fast

Step 2 : $NO_3(g) + NO_2(g) \rightarrow 2NO_2(g) + O(g)$: Slow

Step 3 : $N_2O_5(g) + O(g) \rightarrow 2NO_2(g) + O_2(g)$: Fast

Show that the above mechanism is consistent with the rate law of the reaction. **(80 *marks*)**

(*b*) An ideal binary-liquid mixture was prepared by mixing two liquids of **A** and **B** in a closed evacuated container at temperature *T*. After establishing the equilibrium at temperature *T*, partial pressures of **A** and **B** in the vapour phase are P_A and P_B, respectively. At temperature *T*, the saturated vapour pressures of **A** and **B** are P_A° and P_B°, respectively. Mole fractions of **A** and **B** in solution are X_A and X_B, respectively.

(i) Show that $P_A = P_A^\circ X_A$

(Consider that the rates of vaporization and condensation are equal at equilibrium.)

(ii) In the above system at 300 K, the total pressure was 5.0×10^4 Pa. The saturated vapour pressures of pure **A** and **B** at 300 K, are 7.0×10^4 Pa and 3.0×10^4 Pa, respectively.

I. Calculate the mole fraction of **A** in the liquid phase of the equilibrium mixture.

II. Calculate the vapour pressure of **A** in the equilibrium mixture.

(70 *marks*)

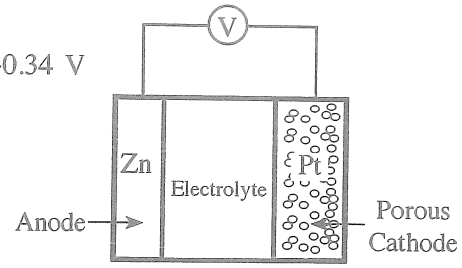
[*see page eleven*

7. (*a*) (i) To compare the properties of Electrolytic and Galvanic cells, copy and complete the following table using the given terms.

Terms: anode, cathode, positive, negative, spontaneous, non-spontaneous.

		Electrolytic cell	Galvanic cell
A.	Oxidation half-reaction takes place at		
B.	Reduction half-reaction takes place at		
C.	Sign of E°_{cell}		
D.	Electron flow	From ..... to	From ..... to .....
E.	Spontaneity of the cell reaction		

(ii) An electrochemical cell was constructed at 300 K by using a Zn(s) anode, an aqueous alkaline electrolyte and a porous Pt cathode which facilitates the collection of oxygen $O_2(g)$ from air as shown below. As the cell operates ZnO(s) is produced.



You are given that

$E^\circ_{ZnO(s)\,|\,Zn(s)\,|\,OH^-(aq)} = -1.31$ V and $E^\circ_{O_2(g)\,|\,OH^-(aq)} = +0.34$ V

Zn = 65 g mol^{-1}, O = 16 g mol^{-1} and

1 *F* = 96,500 C

I. Write the half-reactions occurring at anode and cathode.

II. Write the overall cell reaction.

III. Calculate the cell potential E°_{cell} at 300 K.

IV. State the direction of migration of $OH^-(aq)$ ions between the electrodes.

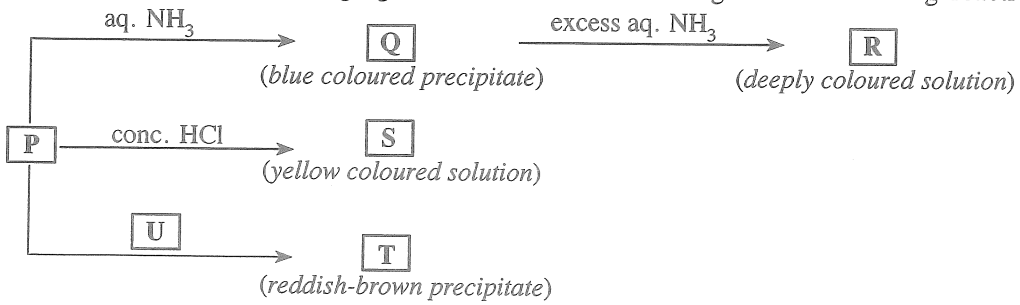
V. When the cell operates for a period of 800 s at 300 K, 2 mol of $O_2(g)$ are consumed.

A. Calculate the number of moles of electrons passing through the cell.

B. Calculate the mass of ZnO(s) formed.

C. Calculate the current passing through the cell. ***(75 marks)***

(*b*) A coloured complex ion **P** is formed when the salt $M(NO_3)_n$ is dissolved in distilled water. **M** is a transition element belonging to the 3*d* block. **P** undergoes the following reactions.



T and **U** are coordination compounds each containing four elements. **P**, **R** and **S** are complex ions.

(i) Identify the metal **M**. Give the oxidation state of **M** in complex ion **P**.

(ii) Give the value of n in $M(NO_3)_n$.

(iii) Write the complete electronic configuration of **M** in complex ion **P**.

(iv) Write the chemical formulae of **P**, **Q**, **R**, **S**, **T** and **U**.

(v) Give the IUPAC names of **P**, **R**, **S**, **T** and **U**.

(vi) What is the colour of **P**?

(vii) What would you expect to observe in I and II given below?

I. When H_2S gas is passed into an acidic solution containing **P** at room temperature

II. When the mixture obtained in I above is heated with dilute HNO_3 after the removal of dissolved H_2S

(viii) Briefly describe a method with the aid of balanced chemical equations for determining the concentration of M^{n+} present in an aqueous solution, using the following chemicals.

KI, $Na_2S_2O_3$ and starch. ***(75 marks)***

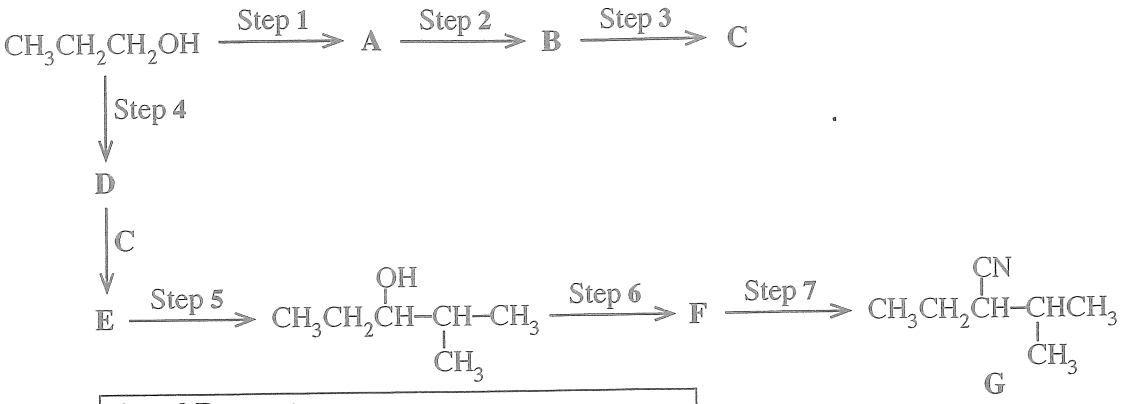
[see page twelve

PART C — ESSAY

Answer two questions only. (Each question carries **150** *marks.)*

8. (*a*) (i) Given below is a reaction scheme for the synthesis of compound **G** using $CH_3CH_2CH_2OH$ as the only organic starting compound.

Complete the reaction scheme by drawing the structures of compounds **A, B, C, D, E** and **F** and writing the appropriate reagents for steps **1 – 7**, selected only from those given in the list.

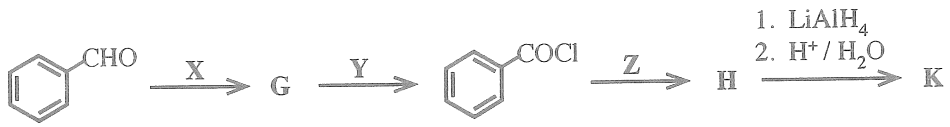


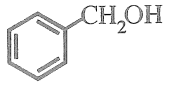
List of Reagents
HBr, PBr_3, pyridiniumchlorochromate (PCC), Mg / dry ether, KCN, conc. H_2SO_4, dil. H_2SO_4

(52 *marks*)

(ii) Consider the following series of reactions.

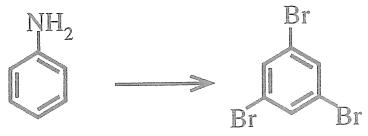
Draw the structures of compounds **G, H** and **K**. Give the reagents **X, Y** and **Z**.



Note that **K** gives benzyl alcohol () when reacted with $NaNO_2$/ dil. HCl.

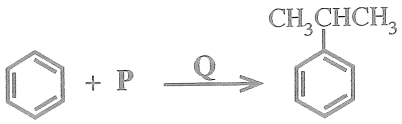
(24 *marks*)

(*b*) (i) Show how the following conversion could be carried out in **not more than three** steps.



(20 *marks*)

(ii) Consider the following reaction.



Identify the chemical substances **P** and **Q** necessary to carry out this reaction.
Write the mechanism of this reaction. **(20 *marks*)**

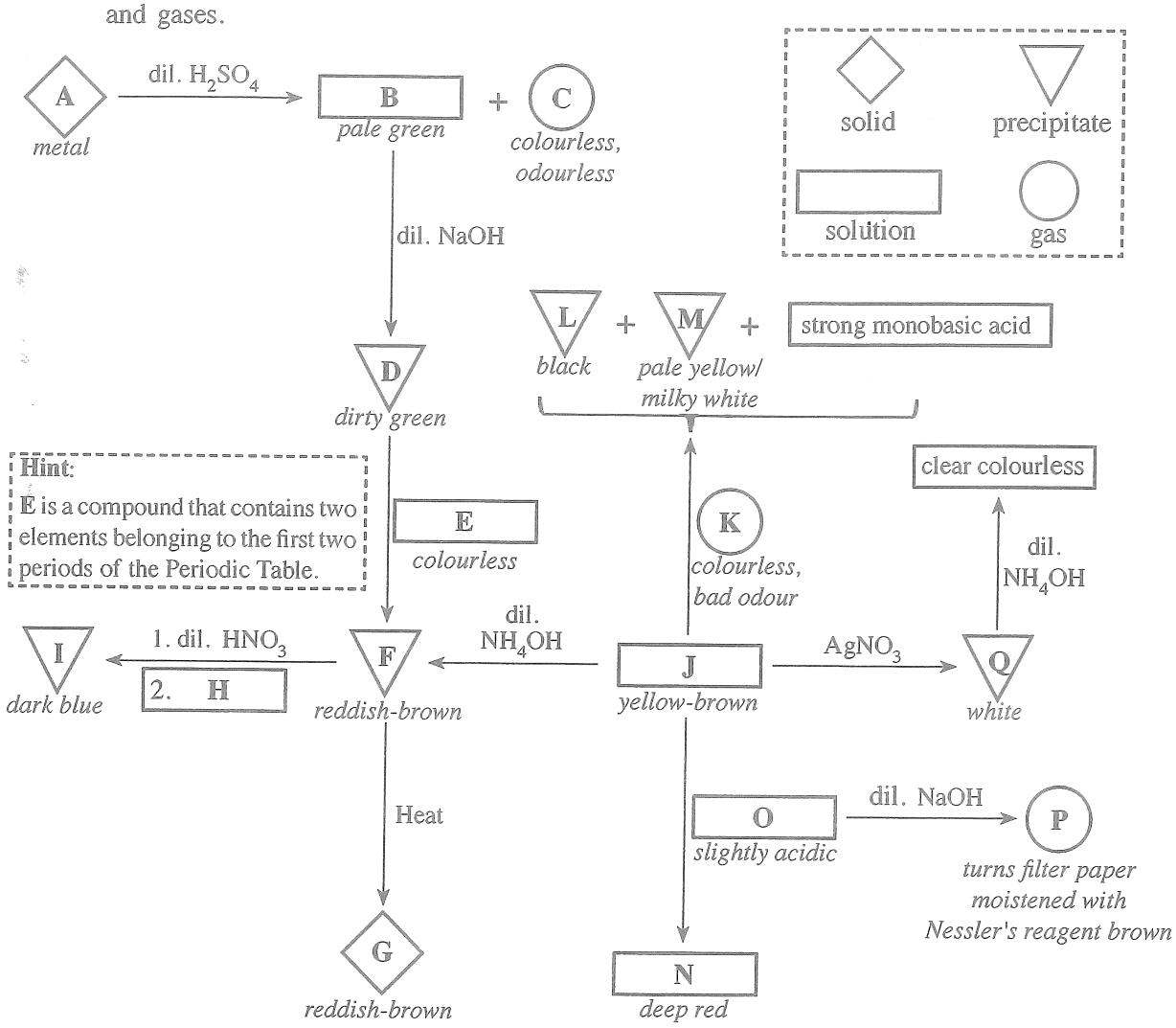
(*c*) (i) Explain why phenol is more reactive in electrophilic substitution reactions than benzene, by considering their resonance hybrids.

(ii) Illustrate the difference in reactivity between phenol and benzene as given in (i) above by means of a suitable reaction.

(iii) Draw the structure(s) of product(s) you described in the reaction in (ii) above. **(34 *marks*)**

[*see page thirteen*

9. (*a*) (i) Write the chemical formulae of the substances **A** – **Q** given in the flow chart below.
(**Note**: Chemical equations and reasons are not expected for the identification of substances **A** – **Q**.)
The symbols given in the box (dash lines) are used to represent solids, precipitates, solutions and gases.



(ii) Write the complete electronic configuration of **A**.

(iii) State the function of **E** in the conversion of **D** to **F**. Give the relevant balanced chemical equations for the stated function. **(75 *marks*)**

(*b*) The solid **X** contains only Cu_2S and CuS. The following procedure was used to determine the percentage of Cu_2S in **X**.

Procedure

A 1.00 g portion of solid **X** was treated with 100.00 cm^3 of 0.16 mol dm^{-3} $KMnO_4$ in dilute H_2SO_4 medium. This reaction gave Mn^{2+}, Cu^{2+} and SO_4^{2-} as products. Thereafter, the excess $KMnO_4$ in this solution was titrated with 0.15 mol dm^{-3} Fe^{2+} solution. The volume required for the titration was 35.00 cm^3.

(i) Write the balanced ionic equations for the reactions taking place in the above procedure.

(ii) Based on the answers to (i) above, determine the molar ratio between,

I. Cu_2S and $KMnO_4$
II. CuS and $KMnO_4$
III. Fe^{2+} and $KMnO_4$

(iii) Calculate the percentage by weight of Cu_2S in **X**. (Cu = 63.5, S = 32) **(75 *marks*)**

[*see page fourteen*

10. (*a*) The following questions are based on the properties of titanium dioxide (TiO_2) and its manufacture carried out by the "Chloride Process".

(i) Name the raw materials used in this process.

(ii) Briefly describe the manufacturing process of TiO_2 giving balanced chemical equations where applicable.

(iii) State **three** properties of TiO_2 and give one use each, relevant to each property.

(iv) If you were to consider establishing a TiO_2 manufacturing plant in Sri Lanka, state **three** requirements that need to be fulfilled.

(v) Does the manufacturing process described in (ii) above contribute to global warming? Justify your answer. **(50 *marks*)**

(*b*) Currently, global warming due to change in greenhouse effect is significantly greater than that before the industrial revolution.

(i) Explain briefly what is meant by greenhouse effect.

(ii) Identify the major environmental problem that occurs due to global warming.

(iii) State **two main** natural gases that contribute to global warming.

(iv) Explain briefly how microorganisms contribute to the release of the gases you stated in (iii).

(v) In addition to the gases you stated in (iii), name **two** classes of synthetic volatile compounds that directly contribute to the global warming, and selecting one compound from each class, draw their structures.

(vi) Select **one** class of compounds from the two classes you stated in (v) that contributes to the catalytic degradation of ozone in the upper atmosphere.

(vii) The slow down of industrial activities due to the Covid-19 pandemic temporarily eased the global environmental issues in many countries. Justify this statement by using **two** main global environmental issues you have learnt. **(50 *marks*)**

(*c*) The following questions are based on the polymers given below.

Polyvinyl chloride (PVC), Polyethylene (PE), Polystyrene (PS), Bakelite, Nylon 6.6, Polyethylene terephthalate (PET), Gutta percha

(i) Draw the repeating units of **four** of the above polymers.

(ii) Categorize each of the above seven (7) polymers as either,

I. natural or synthetic polymers.

II. addition or condensation polymers.

(iii) Name the **two** monomers used in the formation of bakelite.

(iv) Polymers can be grouped into two categories based on their thermal properties. State these **two** categories. Write to which of these categories PVC and bakelite belong.

(v) Give **one** use each for **three** of the polymers given in the above list. **(50 *marks*)**

* * *

[*see page fifteen*

The Periodic Table

1	1 H																2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	La-Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	Ac-Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr