الجامعة الوطنية
National University
Science & Technology للعلوم والتكنولوجيا
كلية عمان البحرية الدولية
International Maritime College Oman

Final Exam
PT-TICHEM: INDUSTRIAL CHEMISTRY
Fall 2025

Points of attention:

- For each question, the maximum earned points are specified in the question.
- Write clearly! Answers that are not readable are not marked and don't earn marks!
- All answers should be written in English using **blue or black pens** only.
- Use the pencil only for diagrams and graphs.
- Show all the calculation steps in the given space.
- When finished, submit the question paper, together with the answer scripts and the signed cover page to the invigilator.
- Any cheating/copying may result in an instant failing of the examination.

Exam Duration:	2 hrs. 30 min.
Instructor's Name:	Dr. G. CHANDRASEKAR
Exam Date:	06/01/2026
Program:	PE

	40
	10

Student Information			
Name:		ID:	
Signature:			

Invigilator			
Initials:		☐ Student ID checked	
Time received:			

Question 1: Multiple choice questions (MCQ) **[5 marks]**

Answer all the questions below: (5 x 1 = 5 marks)

(i) Select the product showed below is obtained from saponification reaction.

(a) H_2SO_4 (b) Sodium carbonate

(c) Ammonia (d) Soap

(ii) The valuable byproduct obtained from saponification process is

(a) Glycerol (b) Sodium hydroxide

(c) Surfactant (d) Citric acid

(iii) The range of pore size of the membrane used in reverse osmosis (RO) is

(a) 1.0 - 10.0 nm (b) 0.15 -2.0 nm

(c) 0.1-1.0 nm (d) > 0.1 nm

(iv) The cleansing action of soap is due to the formation of:

(a) Esters (b) Scum

(c) Micelles (d) Acids

(v) The lime-soda process works on the principle of:

(a) Ion exchange (b) Adsorption

(c) Precipitation (d) Distillation

Question 2: Fill in the blank with correct answers **[5 marks]**

(5 x 1 = 5 marks)

Answer all the questions below:

(i) Quaternary ammonium hydroxide group present in _____ ion exchange resin.

(ii) The calcium carbonate equivalence of 500 mg of $MgSO_4$ is _____ mg/L.

(iii) Alum is used as _____ in the water treatment.

(iv) Soft water is produced from zeolite process by the exchange of Ca^{2+}, Mg^{2+} ions with_____ ion.

(v) The soft soap specially used for babies is produced by using _____ alkali.

Question 3: **[10 marks]**

Thermax Limited produces steam for their unit operations using underground. The water analysis reports revealed that the water contains $MgSO_4$, Ca_2CO_3, $MgCl_2$, $Mg(HCO_3)_2$ and $CaCl_2$ and $Sr(OH)_2$. From this information answer the following questions,

(i) Design the ion exchange resin reactor to remove the cations and anions. (2 marks)

(ii) Explain briefly to remove the cations and anions present in the ground water with suitable chemical equations. (3 marks)

(iii) Calculate the temporary, permanent, and total hardness from water analysis data as given below. (5 marks)

S.No.	Components	Concentrations
1.	$Mg(HCO_3)_2$	35.8 mg/L
2.	$MgSO_4$	19 mg/L
3.	$CaCl_2$	12 ppm
4.	$CaCO_3$	38 ppm
5.	$MgSO_4$	44.0mg/L
6.	$Sr(OH)_2$	1 ppm

Question 4: **[10 marks]**

The manager of the laundry unit in snow-white detergents company demonstrated the usage of detergent to remove the grease on the worker's uniform. If you were the manager, how would you,

(i) Explain the cleansing action of detergent on the dirty clothes with neat sketch. (4 marks)

(ii) Draw the structure of bio-degradable and non-biodegradable detergents structures. (3 marks)

(iii) Demonstrate the synthesis method of soap used for babies with their chemical structures. (3 marks)

Question 5: **[10 marks]**

Limestone is used as raw materials for the sodium carbonate production by Solvay process.

(i) In the process, why 0°C is maintained during the addition of CO_2, Ammonia and NaCl. (1 mark)

(ii) Provide the complete chemical equations on heating the compounds as shown below.

$CaCO_3$ ➔ (2 marks)

$NaHCO_3$ ➔ (2 marks)

(iii) A company in South Australia, called Penrice Soda Products Pty Ltd, produces 850 000 tons per year of soda ash (sodium carbonate). How many tons of calcium carbonate are needed to produce this? (5marks)

Take the overall equation as, $CaCO_{3(s)} + 2NaCl_{(aq)}$ ➔ $Na_2CO_{3(aq)} + CaCl_{2(aq)}$

IUPAC Periodic Table of the Elements

1																		18
1 **H** hydrogen 1.0080 ±0.0002	2											13	14	15	16	17	2 **He** helium 4.0026 ±0.0001
3 **Li** lithium 6.94 ±0.06	4 **Be** beryllium 9.0122 ±0.0001											5 **B** boron 10.81 ±0.02	6 **C** carbon 12.011 ±0.002	7 **N** nitrogen 14.007 ±0.001	8 **O** oxygen 15.999 ±0.001	9 **F** fluorine 18.998 ±0.001	10 **Ne** neon 20.180 ±0.001
11 **Na** sodium 22.990 ±0.001	12 **Mg** magnesium 24.305 ±0.002	3	4	5	6	7	8	9	10	11	12	13 **Al** aluminium 26.982 ±0.001	14 **Si** silicon 28.085 ±0.001	15 **P** phosphorus 30.974 ±0.001	16 **S** sulfur 32.06 ±0.02	17 **Cl** chlorine 35.45 ±0.01	18 **Ar** argon 39.95 ±0.16
19 **K** potassium 39.098 ±0.001	20 **Ca** calcium 40.078 ±0.004	21 **Sc** scandium 44.956 ±0.001	22 **Ti** titanium 47.867 ±0.001	23 **V** vanadium 50.942 ±0.001	24 **Cr** chromium 51.996 ±0.001	25 **Mn** manganese 54.938 ±0.001	26 **Fe** iron 55.845 ±0.002	27 **Co** cobalt 58.933 ±0.001	28 **Ni** nickel 58.693 ±0.001	29 **Cu** copper 63.546 ±0.003	30 **Zn** zinc 65.38 ±0.02	31 **Ga** gallium 69.723 ±0.001	32 **Ge** germanium 72.630 ±0.008	33 **As** arsenic 74.922 ±0.001	34 **Se** selenium 78.971 ±0.008	35 **Br** bromine 79.904 ±0.003	36 **Kr** krypton 83.798 ±0.002
37 **Rb** rubidium 85.468 ±0.001	38 **Sr** strontium 87.62 ±0.01	39 **Y** yttrium 88.906 ±0.001	40 **Zr** zirconium 91.224 ±0.002	41 **Nb** niobium 92.906 ±0.001	42 **Mo** molybdenum 95.95 ±0.01	43 **Tc** technetium [97]	44 **Ru** ruthenium 101.07 ±0.02	45 **Rh** rhodium 102.91 ±0.01	46 **Pd** palladium 106.42 ±0.01	47 **Ag** silver 107.87 ±0.01	48 **Cd** cadmium 112.41 ±0.01	49 **In** indium 114.82 ±0.01	50 **Sn** tin 118.71 ±0.01	51 **Sb** antimony 121.76 ±0.01	52 **Te** tellurium 127.60 ±0.03	53 **I** iodine 126.90 ±0.01	54 **Xe** xenon 131.29 ±0.01
55 **Cs** caesium 132.91 ±0.01	56 **Ba** barium 137.33 ±0.01	57-71 lanthanoids	72 **Hf** hafnium 178.49 ±0.01	73 **Ta** tantalum 180.95 ±0.01	74 **W** tungsten 183.84 ±0.01	75 **Re** rhenium 186.21 ±0.01	76 **Os** osmium 190.23 ±0.03	77 **Ir** iridium 192.22 ±0.01	78 **Pt** platinum 195.08 ±0.02	79 **Au** gold 196.97 ±0.01	80 **Hg** mercury 200.59 ±0.01	81 **Tl** thallium 204.38 ±0.01	82 **Pb** lead 207.2 ±1.1	83 **Bi** bismuth 208.98 ±0.01	84 **Po** polonium [209]	85 **At** astatine [210]	86 **Rn** radon [222]
87 **Fr** francium [223]	88 **Ra** radium [226]	89-103 actinoids	104 **Rf** rutherfordium [267]	105 **Db** dubnium [268]	106 **Sg** seaborgium [269]	107 **Bh** bohrium [270]	108 **Hs** hassium [269]	109 **Mt** meitnerium [277]	110 **Ds** darmstadtium [281]	111 **Rg** roentgenium [282]	112 **Cn** copernicium [285]	113 **Nh** nihonium [286]	114 **Fl** flerovium [290]	115 **Mc** moscovium [290]	116 **Lv** livermorium [293]	117 **Ts** tennessine [294]	118 **Og** oganesson [294]

Key:

atomic number
Symbol
name
abridged standard atomic weight

57 **La** lanthanum 138.91 ±0.01	58 **Ce** cerium 140.12 ±0.01	59 **Pr** praseodymium 140.91 ±0.01	60 **Nd** neodymium 144.24 ±0.01	61 **Pm** promethium [145]	62 **Sm** samarium 150.36 ±0.02	63 **Eu** europium 151.96 ±0.01	64 **Gd** gadolinium 157.25 ±0.03	65 **Tb** terbium 158.93 ±0.01	66 **Dy** dysprosium 162.50 ±0.01	67 **Ho** holmium 164.93 ±0.01	68 **Er** erbium 167.26 ±0.01	69 **Tm** thulium 168.93 ±0.01	70 **Yb** ytterbium 173.05 ±0.02	71 **Lu** lutetium 174.97 ±0.01
89 **Ac** actinium [227]	90 **Th** thorium 232.04 ±0.01	91 **Pa** protactinium 231.04 ±0.01	92 **U** uranium 238.03 ±0.01	93 **Np** neptunium [237]	94 **Pu** plutonium [244]	95 **Am** americium [243]	96 **Cm** curium [247]	97 **Bk** berkelium [247]	98 **Cf** californium [251]	99 **Es** einsteinium [252]	100 **Fm** fermium [257]	101 **Md** mendelevium [258]	102 **No** nobelium [259]	103 **Lr** lawrencium [262]

MLO and Bloom's Level of Complexity

Q #	MLO Addressed	Complexity Level	Mark	Remark
1	**1,2,3**	Knowledge, Apply, Analyze	**5**	3 of 4 problems are required
2	**1, 2, 3**	Knowledge, Apply, Analyze	**5**	
3	**1,5**	Design/Create & Evaluate	**10**	
4	**2, 3**	Apply & Analyze	**10**	
5	**1, 3, 4**	Understand, Apply & Evaluate	**10**	