Roll No.													

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST 1

Sem & AY: Odd Sem 2019-20
Course Code: PET 405
Course Name: PETROLEUM CORROSION TECHNOLOGY
Program & Sem: B.Tech & VII (OE)

Date: 12.10.2019
Time: 1.30 PM to 2.30 PM
Max Marks: 40
Weightage: 20%

Instructions:

(i) Read the question properly and answer accordingly.
(ii) Question paper consists of 3 parts.
(iii) Scientific and Non-programmable calculators are permitted.

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries two marks **(5Qx2M=10M)**

1. What are the components to initiate a corrosion process? [0.5*4=2M] (C.O.NO.1) [Knowledge]
2. Atmospheric corrosion severity depends on what factors? [0.5*4=2M] (C.O.NO.1) [Knowledge]
3. State the difference between grain and grain boundary. [1+1=2M] (C.O.NO.1) [Knowledge]
4. What is Gouge and it comes under which type of corrosion? [1+1=2M] (C.O.NO.1) [Knowledge]
5. Define Sulfide Stress Cracking with an example. [1+1=2] (C.O.NO.1) [Knowledge]

Part B [Thought Provoking Questions]

Answer all the Questions. Each question carries five marks. **(4Qx5M=20M)**

6. What is intergranular corrosion and its occur in which type of material? Explain briefly about the intergranular corrosion. [2+3=5] (C.O.NO.1) [Comprehension]

7. How magnesium, aluminium, zinc and iron or steel having tendency to corrode when comes in contact with an environment [1*5=5M]

(C.O.NO.1) [Comprehension]

8. How salts enhance a corrosion process? How hydrogen can induce failure in a metal? [2+3=5M]

(C.O.NO.1) [Comprehension]

9. How the presence of less oxygen ions in a metal part under differential cell accelerates corrosion rate? [1*5=5M]

(C.O.NO.1) [Comprehension]

Part C [Problem Solving Questions]

Answer the Question. The Question carries ten marks. (1Qx10M=10M)

10. Explain any five different types of corrosion with a neat diagram. [2*5=10M]

(C.O.NO.1) [Comprehension]

SCHOOL OF ENGINEERING

Semester: Odd (2019-20)
Course Code: PET 405
Course Name: Petroleum Corrosion Technology
Program & Sem: Petroleum Engineering & VII

Date: 27-09-2019
Time: 1 Hour
Max Marks: 40
Weightage: 20%

Date:
Time:
Max Marks:
Weightage:

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			C/A			
1	1	1	0.5*4	=	2							2
2	1	1	0.5*4	=	2							2

3	1	1	1+1	=	2							2
4	1	1	1+1	=	2							2
5	1	1	1+1	=	2							2
6	1	1				2+3	=	5				5
7	1	1				1*5	=	5				5
8	1	1				2+3	=	5				5
9	1	1				1*5	=	5				5
10	1	1							2*5	=	10	10
	Total Marks				10			20			10	40

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

I here certify that All the questions are set as per the above lines Deepjyoti]

Annexure- II: Format of Answer Scheme

SCHOOL OF ENGINEERING

SOLUTION

Semester: Odd (2019-20)
Course Code: PET 405
Course Name: Petroleum Corrosion Technology
Branch & Sem: Petroleum Engineering & VII

Date: 27-09-2019
Time: 1 Hour
Max Marks: 40
Weightage: 20%

Date:
Time:
Max Marks:
Weightage:

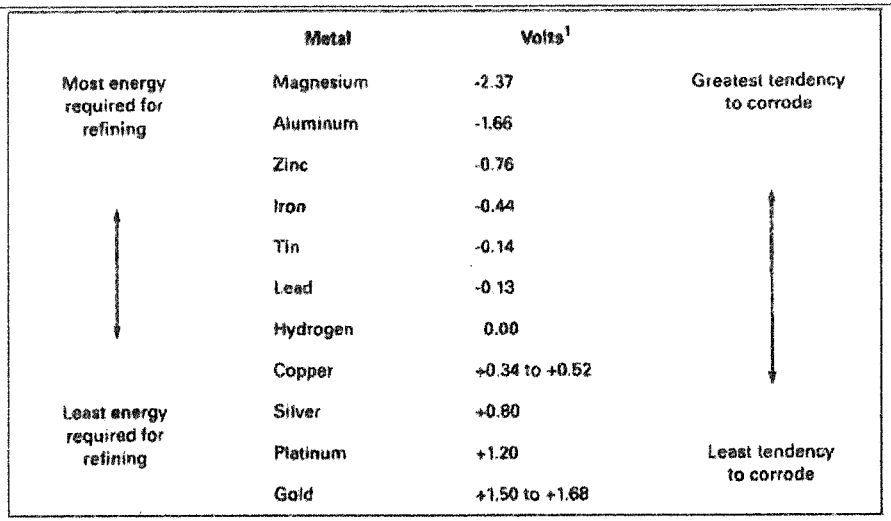
Part A (5 x 2 = 10)

Q No	Solution	Scheme of Marking	Max. Time requ for each Quest
1	Anode, Cathode, Electrolytic medium and Metallic path	0.5*4=2	2
2	1. Industrial and marine or seacoast. 2. Industrial and high humidity. 3. Marine or seacoast. 4. High humidity only.	0.5*4=2	2
3	Grain is a bunch of crystals that consists of a continues arrangement of atoms and all metals are consist of polycrystalline which means that they consist of many grains. Grain boundary is the interface between two grains or crystallites. When metal solidified and cooled, then there is a numerous regions of mismatch and this is called a grain boundary.	1+1=2	2
4	Gouging is a type of corrosion that occurs on a metallic surface in which a hole, groove or indentation is created. It comes under Localised corrosion.	0.5*4=2	2

5	Sulfide stress cracking (SSC) is a form of hydrogen embrittlement which is a cathodic cracking mechanism. Spontaneous brittle failures that occur in steels and other high-strength alloys when exposed to moist H2S and other sulfide environments	1+1=2	2

Part B (4 x 5 = 20)

Q No	**Solution**	**Scheme of Marking**	**Max. Time required each Question**
6	Intergranular corrosion results from a metallurgical structure that causes the grain boundaries to be more susceptible to attack than the grains themselves. Intergranular corrosion has occurred in many alloys including austenitic stainless steels, copper alloys, aluminum alloys, and nickel alloys. Intergranular corrosion is preferential attack of a metal's grain boundaries. (Intergranular corrosion often is confused with stress corrosion cracking. However, intergranular corrosion can occur in the absence of stress; stress corrosion cracking occurs only while the metal is under stress.)	2+3=5	7.5
7	Corrosion is a natural act of metals trying to return to their lowest level of energy. In the case of iron, it is iron ore. Iron ore consists of iron oxides, iron sulfides, iron carbonate, and similar iron compounds. This iron ore is mined, and its energy level is increased as it is processed and converted to steel. From that time on, it is trying to return to the lowest level of energy. Thus, the tendency is for iron to corrode-to become corrosion product. Corrosion products are iron oxides, iron sulfides, iron carbonates, and similar iron compounds. The energy released when the iron converts to corrosion product is, in fact, the energy stored in the metal during the refining and steel making process. This energy supplies the driving force for corrosion. Because corrosion is a natural act, it cannot be prevented-only slowed down. Therefore, corrosion control programs are efforts to postpone the inevitable for the life of the project.	1*5=5	7.5

	 [1] vs standard hydrogen electrode		
8	The presence of salt (or any electrolyte) in the water accelerates the reaction because it increases the conductivity of water, effectively increasing the concentration of ions in the water and so increasing the rate of oxidation (corrosion) of the metal. Hydrogen atoms may be produced on a metal surface in an aqueous environment by a corrosion reaction, cathodic protection, electroplating, or acid pickling. Some of the hydrogen atoms combine to form gaseous molecular hydrogen (H2) on the metal surface and escape as gas bubbles. A portion of the atoms will enter into the metal and may cause problems, such as blistering, cracking, and hydrogen embrittlement. Certain substances, such as sulfide ions, phosphorus, and arsenic compounds, retard the formation of molecular hydrogen and thereby increase the entry of hydrogen into metal.	2+3=5	7.5
9	The ions and electrons are always releases from the anode part and goes to the cathode part in the presence of an electrolytic medium because of the degradation of the metal results in the weight loss of the metal. Thus, in case of differential oxygen cell, the oxygen ions will release from the anode part by comes in contact with the electrolytic medium and that ions will deposit over the cathode apart. Therefore, presence of less oxygen ions in a metal part under differential cell accelerates corrosion rate. As more oxygen ions deposit over cathode part means electrical current will flow more thru the metallic part and makes the corrosion cycle completes and strong.	1*5=5	7.5

Part C (1 x 10 = 10)

Q No	Solution	Scheme of Marking	Max. Time require each Question
10	**Types or Forms of Corrosion** **General**—(overall metal loss, general thinning) **Localized Corrosion**—(pits, gouges, grooves, etc.) Localized attack may be caused by or show up in a number of forms: **Concentration Cells** —(under deposits, in crevices, in cracks) **Galvanic** —(dissimilar metals are connected) **Preferential at Welds** —(related to galvanic) **Erosion/Corrosion and/or Wear/Corrosion** **Microscopic** —(intergranular attack—stress corrosion cracking) **Corrosion Fatigue** **Microbiological Corrosion** —(corrosion associated with bacteria such as sulfate reducers) Other types of localized attack not normally found in oil and gas production: **Leaching (Dezincification)** **Differential Thermal Cell Attack**	2+8=10	20

Uniform or General Corrosion

The metal loss is uniform from the surface.

Often combined with high-velocity fluid erosion, with or without abrasives.

Pitting Corrosion

The metal loss is randomly located on the metal surface.

Often combined with stagnant fluid or in areas with low fluid velocity.

Galvanic Corrosion

Occurs when two metals with different electrode potential is connected in a corrosive electrolytic environment.

The anode metal develops deep pits and groves in the surface.

Crevice Corrosion

Occurs at places with gaskets, bolts and lap joints where crevice exists.

Crevice corrosion creates pits similar to pitting corrosion.

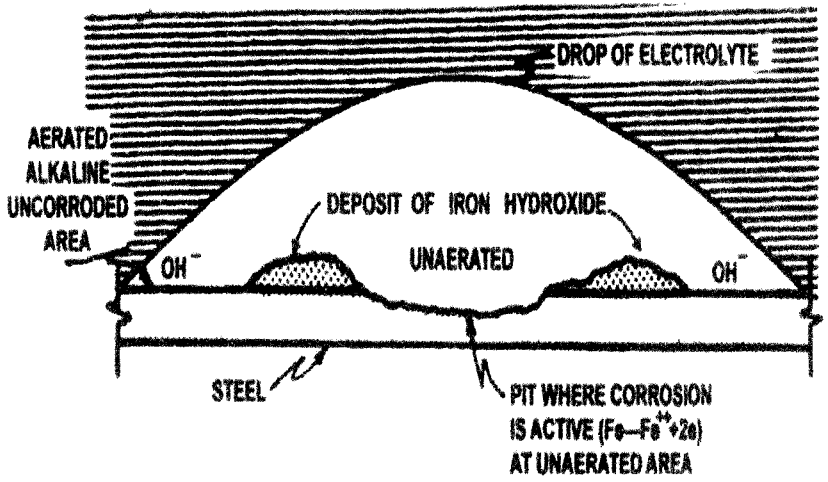
Concentration Cell Corrosion

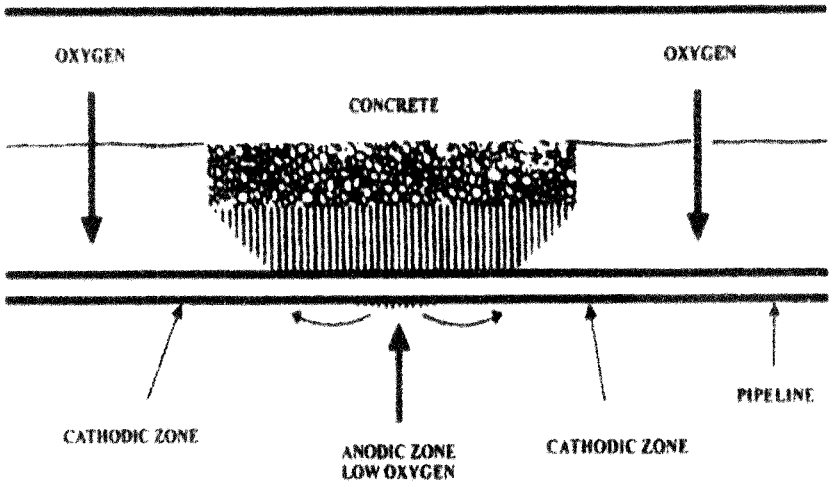
Occurs where the surface is exposed to an electrolytic environment where the concentration of the corrosive fluid or the dissolved oxygen varies.

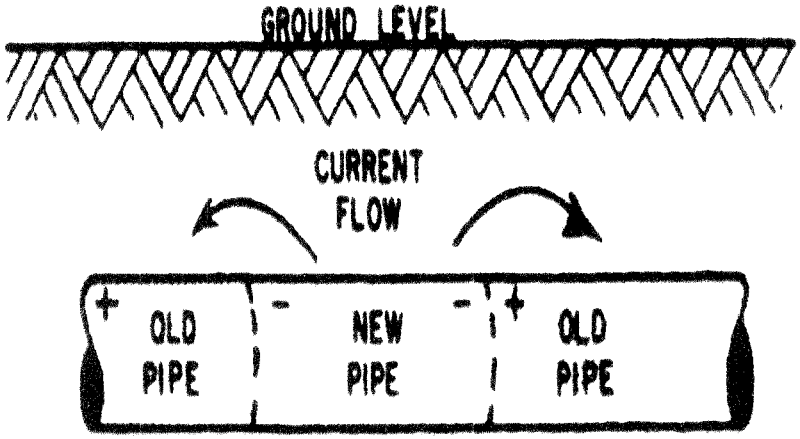
Often combined with stagnant fluid or in areas with low fluid velocity.

Localized corrosion's pits, groves, gouges, and crevices are the results of several different corrosion mechanisms or phenomena. Most of these occur frequently in oilfield environments. The most prevalent form of attack shows up as pitting, sometimes as isolated pits, other times as groups, clusters, or in lines.The configuration depends on the specific details of the environment.

Pitting occurs when the corroding metal suffers metal loss at localized areas rather than over its entire surface. The entire driving force of the corrosion reaction is concentrated at these localized areas. The corrosion rate at the areas being attacked will be many times greater than the average corrosion rate over the entire surface. The pits that result may be large and shallow or narrow and deep.They may be nearly perfectly round or elliptic or have an irregular shape. A measure of pitting severity is the ratio of the deepest metal penetration at the local areas to the average metal penetration calculated by the overall weight loss.







Different diagrams has been discussed above.
The students have to explain any of the above five types of corrosion with a neat diagram.

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GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST - 2

Sem & AY: Odd Sem 2019-20
Course Code: PET 405
Course Name: PETROLEUM CORROSION TECHNOLOGY
Program & Sem: B.Tech (PET) & VII (DE)

Date: 16.11.2019
Time: 1:00 PM to 2:00 PM
Max Marks: 40
Weightage: 20%

Instructions:

(i) Read the question properly and answer accordingly.
(ii) Question paper consists of 3 parts.
(iii) Scientific and Non-programmable calculators are permitted.

Part A [Memory Recall Questions]

Answer all the Questions. **(6Qx2M+1Qx3M=15M)**

1. Define Protective Coating. [1*2=2] (C.O.NO.2) [Knowledge]
2. Name four organic coatings. [0.5*4=2] (C.O.NO.2) [Knowledge]
3. Define fusion bonded coatings. [1*2=2] (C.O.NO.2) [Knowledge]
4. What is Silicon based Vehicle? [1*2=2] (C.O.NO.2) [Knowledge]
5. Define Organic corrosion inhibitor. [1*2=2] (C.O.NO.3) [Knowledge]
6. What is "Chemisorption"? [1*2=2] (C.O.NO.3) [Knowledge]
7. Write different types of coating based on service environment. [1+1+1=3] (C.O.NO.2) [Knowledge]

Part B [Thought Provoking Questions]

Answer all the Questions. Each Question carries five marks. **(3Qx5M=15M)**

8. Curing temperatures may be as high as 175^{O}F (8O^{O}C) for some materials. It's very important to abide by the manufacturer's recommendations to apply proper curing on a metal surface. Which type of curing method is it and explain it briefly? [2+3=5M] (C.O.NO.2) [Comprehension]

9. A successful inhibitor program involves selection of the proper inhibitor, application with a technique that assures that the inhibitor gets a chance to film on the metal surface properly. Justify the above statement with fundamental mechanisms.
[1*5=5] (C.O.NO.3) [Comprehension]

10. Provides an effective bond to the metal substrate. Which type of coat is it and what other functions can perform? [1+4=5] (C.O.NO.2) [Comprehension]

Part C (Problem Solving Questions)

Answer the Question. The Question carries ten marks. (1Qx10M=10M)

11. Suppose, a metal pipe after coating procedure found to form void and cracks in some places. This leads to a corrosion process. Explain how it can be detected through different methods? [2+4+4=10] (C.O.NO.2) [Comprehension]

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

Semester: Odd (2019-20)
Course Code: PET 405
Course Name: Petroleum Corrosion Technology
Program & Sem: Petroleum Engineering & VII

Date: 16-11-2019
Time: 1 Hour
Max Marks: 40
Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels	Thought provoking type [Marks allotted] Bloom's Levels	Problem Solving type [Marks allotted]	Total Marks
			K	C	C	
1	2 (5%)	Unit-II: Protective measurements	2			2
2	2 (5%)	Unit-II: Protective measurements	2			2
3	2 (5%)	Unit-II: Protective measurements	2			2
4	2 (5%)	Unit-II: Protective measurements	2			2
5	3 (5%)	Unit-III: Inhibition and Controlling systems	2			2

6	3 (5%)	Unit-III: Inhibition and Controlling systems	2			2
7	2 (7.5%)	Unit-II: Protective measurements	3			3
8	2 (12.5%)	Unit-II: Protective measurements		5		5
9	3 (12.5%)	Unit-III: Inhibition and Controlling systems		5		5
10	2 (12.5%)	Unit-II: Protective measurements		5		5
11	2 (25%)	Unit-II: Protective measurements			10	10
	Total Marks		10	20	10	40

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

Annexure- II: Format of Answer Scheme

GAIN MORE KNOWLEDGE REACH GREATER HEIGHTS

SCHOOL OF ENGINEERING

SOLUTION

Semester: Odd (2019-20) **Date**: 16-11-2019

Course Code: PET 405 **Time**: 1 Hour

Course Name: Petroleum Corrosion Technology **Max Marks**: 40

Branch & Sem: Petroleum Engineering & VII **Weightage**: 20%

Part A (6Qx2M+1Qx3M=15)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	A coating is any relatively thin material, usually applied as a liquid or powder that, on solidification, is firmly adhered to the surface to be protected, and keeps the environment from contacting the surface.	1*2=2	2
2	Epoxies, vinyls, phenolics, and urethanes.	0.5*4=2	2
3	A special type of material that are applied as a solid powder to a heated metal surface. The melting particles adhere to the hot metal and fuse together to form the coating film.	1*2=2	2
4	It is a synthetic polymer made up of silicon, oxygen and other elements, mostly carbon and hydrogen.	1*2=2	2
5	These are polar organic materials consisting of molecules that have a charge on each end. The polar molecule is often depicted as if it were a tadpole, with a head and a tail.	1*2=2	2
6	The first layer formed may be strongly bonded, perhaps by an electrical charge exchange analogous to a chemical reaction. Such strong bonding is called "chemisorption."	1*2=2	2
7	Atmospheric, Immersion and Underground coatings.	1+1+1=3	3

Part B (3Qx5M=15)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
8	This is a Force curing method for drying of a coating material on the metal surface. Force cured is most likely to be used for internal tank or vessel coating. Force curing is related to air dried, except the vessel is heated (usually with hot air) to speed the drying time. This approach is not applicable to all coatings because if the surface is dried too fast, the evaporation will not be complete and the coating will not be properly cured. Force curing temperatures may be as high as 175^{O}F (8O^{O}C) for some materials. Once again,	2+3=5	5

	it's very important to abide by the manufacturer's recommendations.		
9	Corrosion inhibition is accomplished by 3 fundamental mechanisms. 1. Some inhibitors retard corrosion by adsorption to form an invisibly thin film (monomolecular film); 2. Others form visible bulky precipitates that coat the metal and protect it from attack. 3. Another common mechanism consists of causing the metal to corrode in such a way that a combination of adsorption and corrosion product forms a passive layer. Included in the definition are those substances that, when added to an environment, retard corrosion but do not interact directly with the metal surface. This type of inhibitor causes conditions in the environment to be more favorable for the formation of protective precipitates, or it neutralizes an acidic component in the system.	1*5=5	5
10	It is a Primer or 1st layer of coat which used to apply over the metal surface. Following functions perform- 1. Provides a tie (inter-coat bond) to subsequent coat. 2. May provide a strong resistance to corrosion and chemicals as a barrier. 3. May provide corrosion protection as an inhibitor (inhibitive primer). 4. May provide corrosion protection with sacrificial metal (zinc-rich primer).	1+4=5	5

Part C (1Q x 10M = 10)

Q No	**Solution**	**Scheme of Marking**	**Max. Time required for each Question**
11	The void or cracks on the coated metal pipe can be detected by two methods and they are used to be called as Holiday Detectors. These are explain below- The low-voltage wet sponge holiday detector is applicable for thin-film coatings. The unit that supplies the low-voltage DC is grounded to the metal structure and connected to the wet sponge. As the sponge is passed over the coating, the water will penetrate the holidays and damaged places, completing the circuit and sounding an	2+4+4=10	20

	audible alarm. The water used in the sponge should be tap water with a low sudsing wetting agent. Salt should not be used in the water. Salty water could lead to erroneous indications, and even more important, residual salt on the coating could interfere with the adhesion of additional coats. The sponge speed should be slow enough to detect the holidays (1 Ws [0.3 m/s] is recommended)." For thick-film coatings, a high-voltage spark type holiday detector should be used. The high-voltage unit uses a metal wire whisk or spring assembly (exploring electrode) to contact the coating, rather than the wet sponge. When the electrode reaches a holiday, a spark will jump the air gap to complete the circuit and trigger the alarm. To avoid burning holes in the coating, voltage and current must be controlled for the film thickness involved. The manufacturer can supply the figures for the maximum voltage for the specific coating. NACE RPOl88-90 gives suggested voltages based on dry film thickness.		

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GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Semester: Odd Semester: 2019 - 20 | **Date**: 23 December 2019

Course Code: PET 405 | **Time**: 9.30 AM to 12.30 PM

Course Name: PETROLEUM CORROSION TECHNOLOGY | **Max Marks**: 80

Program & Sem: B.Tech (All Programs) & VII (OE-I) | **Weightage**: 40%

Instructions:

(i) Read the all questions carefully and answer accordingly.
(ii) Question paper consists of 3 parts.
(iii) Scientific and Non-programmable calculators are permitted.

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries 02 marks. **(15Qx2M=30M)**

1. Answer the following questions:

a. Write two basic corrosion resistant materials. (C.O.No.1) [Knowledge]

b. Name four different basic factors due to which corrosion occur. (C.O.No.1) [Knowledge]

c. The size of the driving _____ generated by a metal in a water solution is called the _____. (C.O.No.1) [Knowledge]

d. How is the internal environment of any material gets affected by corrosion? (C.O.No.1) [Knowledge]

e. How many are the types of coatings existing based on service environment? (C.O.No.2) [Knowledge]

f. What are the four common organic coatings? (C.O.No.2) [Knowledge]

g. Define Fusion bonded coating. (C.O.No.2) [Knowledge]

h. List three types of pigment. (C.O.No.2) [Knowledge]

i. What is overall corrosion rate? (C.O.No.3) [Knowledge]

j. Define Coupon. (C.O.No.3) [Knowledge]

k. Name two types of attack caused due to corrosion. (C.O.No.3) [Knowledge]

l. Define 'Etched' in terms of corrosion. (C.O.No.3) [Knowledge]

m. What is NACE? (C.O.No.4) [Knowledge]

n. Why citations are vital? (C.O.No.4) [Knowledge]

o. _____requires to provide the _____ to the caselet. (C.O.No.4) [Knowledge]

Part B [Thought Provoking Questions]

Answer both the Questions. Each Question carries 10 marks. (2Qx10M=20M)

2. The more common criteria involve measurements of voltage (differences in potential) between the protected structure and the electrolyte. Please discuss the criteria and explain the galvanic anode protection method. (C.O.No.2) [Comprehension]

3. Methods for the detection and monitoring of internal corrosion has been the exposure of test specimens. Explain different probe mechanism. (C.O.No.3) [Comprehension]

Part C [Problem Solving Questions]

Answer both the Questions. Each Question carries 15 marks. (2Qx15M=30M)

4. A carbon steel coupon of pipe grade weighing 10.9265 grams and having an exposed area of 2.96 square inches was installed in a process on August 27th. On November 13th, after 78 days in the process, it was removed and cleaned. The weight was found to be 10.5560 grams and density is 7.85 g/cc. Determine the corrosion rate in mmpy. Explain the corrosion and write about the four basic requirements for initiating the corrosion process.

(C.O.No.3) [Application]

5. Iron is the usual form of corrosion products during corrosion process. Name some of those products and also write the name of a bacteria which commonly causes corrosion in the oil and gas industries. Explain various corrosive environments and mention about the various physical parameters affecting the corrosion to form these product.

(C.O.No.1) [Comprehension]

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO (% age of CO)	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels	Thought provoking type [Marks allotted] Bloom's Levels	Problem Solving type [Marks allotted]	Total Marks
			K	C	A/C	
1	C.O No. (1 – 4)	1 - 4	30			30
2	C.O No. 2	3		10		10
3	C.O No. 3	3		10		10
4	C.O No. 3	3			15	15
5	C.O No. 1	2		15	15	15
	Total Marks		30	35/20	15/30	80

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

I hereby certify that all the questions are set as per the above guidelines.

Faculty Signature:

Reviewer Commend:

Format of Answer Scheme

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

SOLUTION

Semester: Odd Sem. 2019-20
Course Code: PET 405
Course Name: PETROLEUM CORROSION TECHNOLOGY
Program & Sem: B.Tech (ALL PROGRAM)-VII Sem (OE-I)

Date: 23.12.2019
Time: 9.30 AM - 12.30 PM
Max Marks: 80
Weightage: 40%

Part A (15Q x 2M = 30Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1 a.	Gold and Stainless steel.	1+1=2	3 min.
b.	Anode, Cathode, Electrolyte solution and Conductive path.	0.5*4=2	3 min.
c.	Voltage and Potential of the metal.	1*2=2	3 min.
d.	Properties of fluid and physical properties.	1+1=2	3 min.
e.	3 types.	1*2=2	3 min.
f.	Epoxies, vinyls, phenolics, and urethanes	0.5*4=2	3 min.
g.	Are a special type of material that are applied as a solid powder to a heated metal surface. The melting particles adhere to the hot metal and fuse together to form the coating film.	1*2=2	3 min.
h.	Inhibitive pigments (only in primers), inert and reinforcing pigments, and color pigments.	0.5*4=2	3 min.
i.	The coupon's weight loss, its surface area, and the exposure Time that defines overall corrosion rate.	1*2=2	3 min.
j.	A coupon is a small piece of metal that is inserted in the system and allowed to corrode.	1*2=2	3 min.
k.	Etched and Overall attack.	1+1=2	3 min.
l.	Etched which would indicate a more or less uniform roughening of the coupon.	1*2=2	3 min.
m.	National Association of Corrosion Engineers	1*2=2	3 min.
n.	It is important to validate our statement as a proof.	1*2=2	3 min.
o.	Diagonosis and solution.	1*2=2	3 min.

Part B (2Q x 10M = 20 Marks)

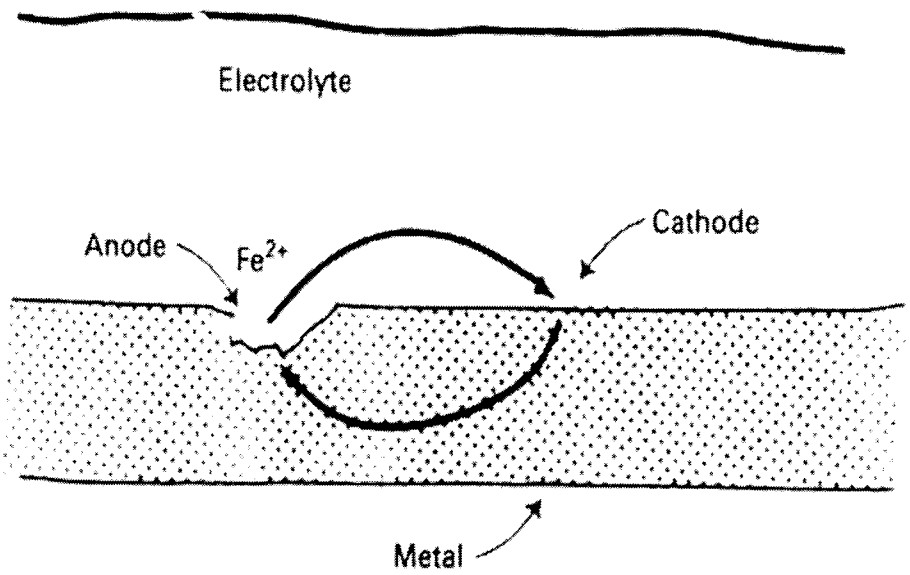
	Solution		Max. Time required for

Q No		Scheme of Marking	each Question
2	Over the years, various criteria have been developed to establish the effectiveness of cathodic protection (CP) on various structures. The more common criteria involve measurements of voltage (differences in potential) between the protected structure and the electrolyte. Probably the most widely used criterion for buried pipes or external tank bottoms involves the use of a copper-copper sulfate electrode as a reference half cell. This electrode consists simply of a copper rod immersed in saturated copper sulfate solution, both being housed in a plastic cylinder with a porous plug on the bottom end (for contact with the electrolyte) and the copper rod extending out the top (for connection to the measuring high-resistance voltmeter or potentiometer). Galvanic Anodes- A galvanic anode by definition is: "a metal which, because of its relative position in the galvanic series, provides protection to metal or metals that are more noble in the series, when coupled in an electrolyte." Galvanic anodes used in oilfield CP are made of special magnesium, aluminum, or zinc alloys, which, when connected to steel, exhibit sufficiently high potentials to develop sufficient current flow through the electrolyte to protect the structure. Magnesium anodes are most widely used in soil applications due to their high driving potential. Magnesium is also used in fresh or condensed waters in vessels. Aluminum anodes are excellent in seawater and brines. Aluminum has the added advantage of an inherently high energy capability per pound of anode. By way of comparison, under ordinary usage, magnesium is consumed at the approximate rate of 17 lbs (7.7 kg) per ampere per year, zinc at a rate of 26 lbs (12.7 kg), and one commercially available aluminum alloy at only 6.8 lbs (3.1 kg). Zinc anodes are not as common in oilfield systems as magnesium and aluminum. Zinc finds its greatest application in low resistivity soils and some waters. However, zinc has a disadvantage-it has the undesirable habit at elevated temperatures of reversing polarity and become cathodic to steel. Thus, care must be exercised when selecting zinc for cathodic protection application. For example, zinc anodes are not a good choice for fired vessels such as emulsion heaters (heater treaters).The reported reversals occur above 140°F (60°C) to 170°F (76.7"C) depending on the water composition. Even if the zinc anode polarity does not reverse, it may passivate at temperatures above 120°F (49°C).	2+3+5=10	30 min.
3	The most common method for the detection and monitoring of internal corrosion has been the exposure of test specimens-pieces of a material placed into the environment to corrode and then be analyzed. This approach includes coupons, test nipples, spool pieces, and special devices using "corrosion probes." It is common in production to "install a coupon" when corrosion in a system is to be evaluated. Many pipelines and process industries also monitor their internal problems with coupons. A coupon is a small piece of metal that is inserted in the system and allowed to corrode. These coupons are carefully cleaned and weighed before and after they are exposed in a system. From the weight loss of the coupon, the corrosion rate can be determined. Pit depths can be measured and pitting rates determined. Coupons also can be used to collect samples of materials that precipitate, deposit, or grow on the surface. As with other tools, coupons are not infallible. There are many variables that can affect the results. Many operators install specially prepared nipples or spools in a line to	2+8=10	30 min.

	serve as large coupons. Such test nipples are often used in connection with other monitoring techniques and may be exposed for several months. The results of their exposure reflect the long-term effects of corrosion. They also represent a 360-degree sampling of the interior pipe surface and give an accurate sampling of dynamic effects. Test nipples may be weighed, and corrosion rates determined as with coupons. Furthermore, the ends of the nipple can be capped and sealed as soon as it is pulled and thus preserve any deposits and corrosion products for laboratory examination and analysis. However, their biggest contribution is usually their physical appearance. The test nipples can be cut open, inspected and pit depths measured. Electrical and electrochemical methods include electrical resistance (ER) probes and linear polarization (LP) probes that measure corrosion rate, galvanic probes that are primarily used as oxygen or inhibitor film detectors, and hydrogen probes that detect corrosion by detecting hydrogen atoms passing through metal. Each technique has its advantages and limitations but all can provide useful information for evaluating corrosion control programs. Chemical analyses come into play at various times in monitoring programs. Sometimes samples are taken when troubleshooting problems, or evaluating procedures (e.g., those collected during injection line pigging) other times the need is for routine monitoring of liquid streams (e.g., dissolved iron in gas well water samples, dissolved oxygen in injection waters, or even glycol samples to determine pH, inhibition levels and glycol quality).		

Part C (2Q x 15M = 30Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
4	Corrosion is a natural process, which converts a refined metal to a more chemically-stable form, such as its oxide, hydroxide, or sulfide. It is the gradual destruction of materials (usually metals) by chemical and/or electrochemical reaction with their environment. The four basic requirements for initiating the corrosion process are- 1. The anode is the area of the metal surface that corrodes-where the metal dissolves (goes into solution). When a metal dissolves, the metal atom loses electrons, and it goes into solution as a metal ion. 2. The cathode is the area of the metal surface that does not dissolve.The electrons from the anode travel through the metal to the cathodic area. At the cathodic area, the electrons, which carry a negative charge, react with ions in the water that carry a positive charge. 3. The electrical current flows in the opposite direction of electron travel. Thus, as electrons flow from the anode area to the cathode area, electrical current flows in the opposite direction, from the cathode to the anode. This current flow is within the metal. 4. To complete the electrical circuit, the metal surface (both the anode and the cathode) must be covered with electrically conductive solution. Such a solution is called an electrolyte.	8+7=15	37.5 min.



Profiling the system becomes quite useful for troubleshooting when changes in corrosion rates and problems occur.

$$\text{CORROSION RATE (mpy)} = \frac{22{,}300 \times \text{Weight Loss (grams)}}{\text{Metal Density (g/cm}^3\text{)} \times \text{Coupon Area (in.}^2\text{)} \times \text{Time (days)}}$$

"Weight Loss" is the weight loss due to corrosion and is determined by subtracting the weight
after cleaning from the initial weight, "Metal Density" is the density of the coupon or coupon alloy from
the following table, "Coupon Area" is the surface area of the coupon that is exposed to the corroding
process, and "Time" is the period in days between installation and removal of the coupon.

$$\frac{22{,}300 \times (10.9265 - 10.5560)}{7.85 \times 2.96 \times 78 days} = 4.56\ mpy$$

=4.56x0.0254
=0.116 mmpy.

5	Iron oxides, iron sulfides, iron carbonates, and similar iron compounds. Desulfovibrio desulfuricans. External Environment: 1. Atmospheric Corrosion- is the deterioration and destruction of a material and its vital properties due to electrochemical as well as the other reactions of its surface with the constituents of the atmosphere surrounding the material. 2. Soil Corrosion- is a geologic hazard that affects buried metals and concrete that is in direct contact with soil or bedrock. Soil corrosion is a complex phenomenon, with a multitude of variables involved. Pitting corrosion and stress-corrosion cracking (SCC) are a result of soil corrosion, which leads to underground oil and gas transmission pipeline failures. 3. Submerged Corrosion- Like soils, the severity of corrosion for facilities in water is largely dependent on the composition and conditions of the water. Internal Environment: Corrosion inside pipes and equipment involves the numerous factors that make up the internal environments. These environments not only involve chemical and physical properties of metals and fluids, they include the physical characteristics of	2+2+6+5=15	37.5 min.

	the system (i.e., temperature, pressure, flow rates, gadoil and water/oil ratios, sizes, times, and schedules). Various physical parameters affecting the corrosion: 1. pH Lower pH pH affects the stability of passive films 2. Dissolved gas Dissolved oxygen Dissolved CO2 and H2S 3. Velocity Increased velocity enhances mass transfer rate Enhance mechanical erosion 4. Temperature Increased T, increases the reaction rate But increased T, decreases the concentration of oxygen Difficult to interpret 5. Pressure 6. Conductivity		