MID-SEMESTER EXAMINATION

Examination: 6th Sem B.Tech (CHM, CIV,ESE, FMME, M&C, MNE, MME, EE, ECE, CSE, M&C, PHY, MLMTE, & PE)

Session: 2024-2025

Semester: Winter

Subject: Coal Mine Methane Recovery and Utilization (MNO304)

Time: 2 hrs

Max. Mark: 30

Instructions: (i) ***Answer ALL questions, (ii) Use desorbed gas fraction chart, if required***

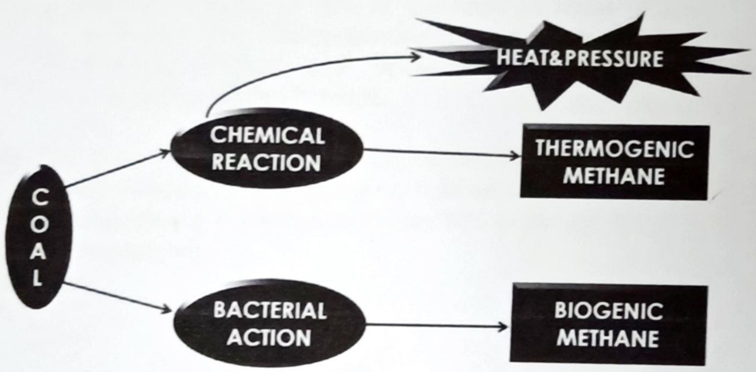
Q.No.	*Question*	*Marks*
1.	Explain with diagrams the formation of coalbed methane and the different phases of methane movement in coal. Solution: **Ans:** CBM in coal is a result of chemical and physical processes. CBM is generated either through chemical reactions or bacterial action. Chemical action occurs over time as heat and pressure are applied to coal in a sedimentary basin, referred to as thermogenic methane. Bacteria obtain nutrition from coal, and produce methane as a by-product, is referred to as biogenic methane.  The movement of methane in the coal was shown in Fig. The three phases of methane movement in coal have been described below: (a) The methane gets desorbed from the internal surface, i.e., the porous structure of the coal matrix (b) Diffusion of methane from the pores to cleat network by following Fick's second law (c) Movement of methane from cleat to production well by following Darcy's law	2+4

Fig. : Movement of methane in coal beds: (a) Desorption from coal surface (b) Diffusion of methane from pore structures to cleats (c) Movement of methane within the cleat

2	a) Explain with diagram the gas adsorption isotherm.	2
	Solution:	2+2

- The adsorption isotherm expresses the relationship between the free phase gas pressure and the mass/volume of gas adsorbed into coal at a constant temperature (isothermal conditions).
- The quantity of gas adsorbed reduces with increase in temperature and increases with increase in pressure. The magnitude of adsorption depends upon the surface pore area of adsorbent (coal) and type of adsorbate (gas).
- Coal is porous and adsorbent rock has significant storage capacity for methane and carbon oxide gases. The gas adsorption storage capacity of coal is measured in terms of adsorption isotherm. The adsorption isotherm depends on coal rank, moisture content and isothermal temperature at which measurement is undertaken.

b) If the desorbing samples of sub-bituminous Cretaceous-age coal from the San Juan Basin will have a coal diffusivity of 7.51×10^{-4} min^{-1}. Calculate the time required to release 90% of the gas and 95% of the gas, respectively.

Solution:

Ans:

We know $t_{D} = \frac{Dt}{r_p^2}$

At 90% of the gas

$0.182986 = 7.51 \times 10^{-4}\ min^{-1}\ t_{90}$

$\Rightarrow t_{90} = 243.66$ min $= 4.1$ hr

At 95% of the gas

$0.253118 = 7.51 \times 10^{-4}\ min^{-1}\ t_{95}$

$\Rightarrow t_{95} = 337.04$ min $= 5.6$ hr

3 What are the major parameters influencing the selection of methane drainage methods in the coal seam? Describe with diagram the suitable conditions of any methane drainage technique. 2+4

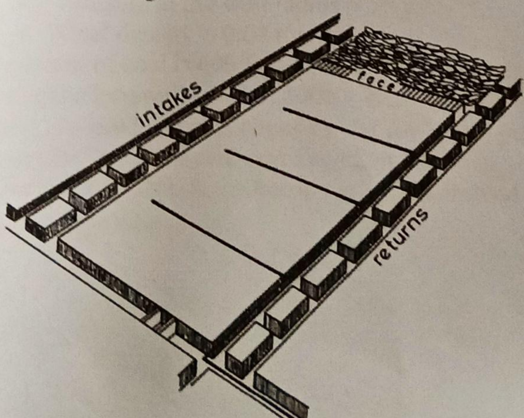
Solution:

The major parameters that influence the choice of methane drainage method include

- the natural or induced permeability of the source seam(s) and associated strata
- the reason for draining the gas the method of mining
- Gassiness of coal seams
- Method of mining

In-seam drainage

- In-seam drainage is successful only if permeability of coal is high.
- If the coal permeability is sufficiently high, methane flow into mine workings can be reduced significantly by pre-draining the seam to be worked.
- Using down-the-hole motors and steering mechanisms, boreholes may be drilled to lengths of 1000 m within the seam.
- Boreholes are drilled into the seam from the return airway and connected into the methane drainage pipe system.
- The preferred spacing of the holes depends upon the permeability of the seam and may vary from 10 to over 80 m.
- The distance from the end of each borehole and the opposite airway should be about half the spacing between holes.
- The application of suction on the boreholes is often unnecessary but may be required for coals of marginal permeability or to increase the zone of influence of each borehole.
- The time allowed for drainage should be at least six months and, preferably, over one year.
- Hence, the holes should be drilled during the development of the tailgate of the longwall.



4	What is hydraulic fracturing? Describe the applications of any two hydraulic fracturing fluids for stimulation treatment of coalbed gas wells. Solution: Hydraulic fracturing is the process of transmitting pressure by fluid or gas to create cracks or to open existing cracks in hydrocarbon bearing rocks underground. The purpose of hydraulic fracturing is to breakdown the coal and create fractures that allow gas to flow through the coal matrix to the fractures and then to the wellbore, a process known as stimulation. • **Plain water**: Plain water hydraulic fracturing is pumping coproduced or formation water and/or treated water to stimulate the coal reservoir. This treatment is preferred for highly fractured coal reservoirs where water pressure can be applied and still achieve enlarging and lengthening fracture, and cleat systems. • **Foam gels and Gas**: Hydraulic fracturing with foam, which is formed by trapped gas, is used to carry proppants into the fracture and cleat systems in coal reservoirs. The combined foam and gelled fluids are valuable in coal reservoirs with low permeability and hydrostatic pressure.	2+4
5	a) Calculate the steady-state gas production from a vertical well for the following given conditions: • Permeability of coal = 3 md • Thickness of the coal seam = 40 ft • Average viscosity of gas = 0.02 cp • Average compressibility factor = 0.90 • Temperature = 60 °F • The radius of the well = 0.25 ft • External radius = 1000 ft • Pressure at external radius = 500 psi • Pressure at the well radius = 50 psi. • Coal density = 0.04 ton/ft^3 If the gas content of coal is 600 ft^3/ton, how many fracture wells will be needed to degas a longwall panel of 1000 × 10,000 ft in 5 years? Assume that the total gas production declines by the following power law with the characteristic 'n' of the coal seam equal to 0.8: $Q = At^n$, where Q is the cumulative gas production, A is the initial production, t is the time in day. Solution	3+3

Calculate gas and water flow from a well producing steadily under the following conditions:

$k = 0.003$ darcy (3 md)
$h = 40$ ft
$\mu = 0.02$ cp
$z = 0.90$
$T = 60°F\ (+460)$
$r_e = 1000$ ft
$r_w = 0.25$ ft
$p_e = 500$ psi
$p_w = 50$ psi

Using Eq. (15.4),

$$Q = \frac{707.8 \times (0.003)40(500^2 - 50^2)}{0.9 \times 520 \times (0.02) \times \ln\left(\frac{1,000}{0.25}\right)}$$

$$= 270.9 \text{ MCFD}$$

Cumulative gas production = 270900 × $(365*5)^{0.8}$ = 110,108,108 ft^3
Number of wells = (1000*10000*40*0.04*600)/(110,108,108)= 87

P.T.O

END

FORMULA

$$Q = \frac{707.8\, kh\,(p_e^2 - p_w^2)}{\mu z T ln(r_e/r_w)}$$

Table:
Desorbed gas fraction

t_{Ds}	V/V_t	t_{Ds}	V/V_t	t_{Ds}	V/V_t
7.375E-06	0.01	0.012420	0.34	0.065540	0.67
3.521E-05	0.02	0.013258	0.35	0.068363	0.68
7.980E-05	0.03	0.014130	0.36	0.071300	0.69
1.426E-04	0.04	0.015038	0.37	0.074356	0.70
2.241E-04	0.05	0.015982	0.38	0.077538	0.71
3.244E-04	0.06	0.016963	0.39	0.080855	0.72
4.440E-04	0.07	0.017983	0.40	0.084315	0.73
5.832E-04	0.08	0.019042	0.41	0.087928	0.74
7.423E-04	0.09	0.020142	0.42	0.091704	0.75
9.216E-04	0.10	0.021283	0.43	0.095656	0.76
0.001122	0.11	0.022467	0.44	0.099797	0.77
0.001342	0.12	0.023696	0.45	0.104142	0.78
0.001585	0.13	0.024969	0.46	0.108710	0.79
0.001849	0.14	0.026290	0.47	0.113519	0.80
0.002135	0.15	0.027658	0.48	0.118594	0.81
0.002443	0.16	0.029077	0.49	0.123962	0.82
0.002775	0.17	0.030547	0.50	0.129653	0.83
0.003130	0.18	0.032069	0.51	0.135707	0.84
0.003509	0.19	0.033647	0.52	0.142167	0.85
0.003912	0.20	0.035282	0.53	0.149088	0.86
0.004341	0.21	0.036975	0.54	0.156536	0.87
0.004794	0.22	0.038730	0.55	0.164594	0.88
0.005273	0.23	0.040547	0.56	0.173366	0.89
0.005779	0.24	0.042430	0.57	0.182986	0.90
0.006312	0.25	0.044382	0.58	0.193631	0.91
0.006872	0.26	0.046404	0.59	0.205540	0.92
0.007460	0.27	0.048500	0.60	0.219051	0.93
0.008077	0.28	0.050674	0.61	0.234656	0.94
0.008723	0.29	0.052927	0.62	0.253118	0.95
0.009400	0.30	0.055265	0.63	0.275721	0.96
0.010107	0.31	0.057691	0.64	0.304867	0.97
0.010846	0.32	0.060209	0.65	0.345947	0.98
0.011617	0.33	0.062823	0.66	0.416180	0.99
				0.649538	0.999

V = desorbed gas volume

V_t = total desorbed gas volume.

[t_{Ds} = dimensionless time
$V|V_t$ = desorbed gas fraction.]