

National Exams December 2016

98-Pet-B4, Petroleum Geology

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is a CLOSED BOOK exam.
3. Candidates may use one of two calculators, the Casio or Sharp approved models.
4. FIVE (5) sections constitute a complete exam paper. Each section contains between 2 and 5 questions.
5. The first five sections as they appear in the answer book will be marked.
6. All sections are of equal value. All parts in a multipart question have equal weight unless otherwise stated.
7. Clarity and organization of your answers are important, clearly explain your logic.
8. Pay close attention to units, some questions involve oilfield units, and these should be answered in the field units. Questions that are set in other units should be answered in the corresponding units.
9. Useful formulas are provided at the end of questions.

Section 1 – Source Rock Geology and Hydrocarbon Generation (20 Marks)

Q1-1 (5 marks) What are the five conditions necessary for a commercial accumulation of petroleum?

Q1-2 (8 marks) Define the following terms:

- a) Lignin
- b) Vitrinite
- c) Sapropelic kerogen
- d) Catagenesis

Q1-3 (7 marks) Draw a cross section through a silled-basin (maximum 1500 m deep; e.g., Black Sea) that is salinity stratified and transitions from oxygenated surface waters (upper 100 m) to anoxic water at depth (below 300 m) (2 of 7 marks). Indicate the relative organic carbon concentrations (as a percentage range) you would expect to be preserved in the lake sediments along the lake-bed profile (3 of 7 marks), and the expected dissolved oxygen concentrations in the seawater at different depths (2 of 7 marks).

Section 2 – Hydrocarbon Chemistry and Physical Properties (20 Marks)

Q2-1 (8 marks) Provide the API gravity and viscosity of a typical:

- a) Heavy oil
- b) Light oil
- c) Bitumen
- d) Water

Q2-2 (8 marks) Provide the chemical formula and draw the structural formula for the following hydrocarbon compounds:

- a) Octane
- b) Benzene
- c) Ethane
- d) Phenol

Q2-3 (4 marks) The density of oil is often given in API. What is the formula for calculating API? What is the typical API range for light oil? Heavy oil?

Section 3 – Unconventional – Oilsands & Tight Oil (20 Marks)

Q3-1 (4 marks) Define the following terms:

- a) Tight oil
- b) Halo oil
- c) Bitumen
- d) SAGD

Q3-2 (4 marks) What is the best method(s) (e.g., drilling, completion, etc.) for developing a tight-oil reservoir? Why?

Q3-3 (4 marks) Describe and illustrate two method(s) (e.g., drilling, completion, etc.) for developing a bitumen-saturated sandstone reservoir.

Q3-4 (8 marks) Draw a cross-section of a bitumen-saturated estuarine point-bar deposit including potential well placement and completion strategy. Label the diagram, show lithologies, and include a scale (4 of 8 marks). What reservoir characteristics can impact the efficiency and economic viability of extracting oil from this reservoir (4 of 8 marks)?

Section 4 – Unconventional – Shale Gas & Coal Bed Methane (20 Marks)

Q4-1 (4 marks) What are the main differences between shale gas and tight gas plays?

Q4-2 (4 marks) Provide the typical matrix permeability and porosity ranges for economically exploited shale gas plays.

Q4-3 (6 marks) Besides matrix porosity and permeability, what rock and reservoir characteristics impact the economic exploitation of shale gas?

Q4-4 (2 marks) Why is coal-bed methane considered unconventional?

Q4-5 (2 marks) What is the difference between a face cleat and a butt cleat?

Q4-6 (2 marks) How is gas stored in a coal bed?

Section 5 – Carbonate Traps (20 Marks)

Q5-1 (8 marks) Define and illustrate the following:

- a) Rimmed platform
- b) Ramp
- c) Sabkha
- d) Lagoon

Q5-2 (10 marks) Draw a cross-section and plan-view map of a detached carbonate bank (2 of 10 marks). Indicate the geomorphic features (distinct depositional environments) of the carbonate bank, and the dominant and subordinate wind directions (3 of 10 marks). Briefly describe the potential of carbonate bank sub-environments as hydrocarbon reservoirs assuming they undergo no diagenesis, and that the bank is preserved in the subsurface and has been charged with hydrocarbons (5 of 10 marks). Don't forget a scale and be sure to label everything clearly.

Q5-3 (2 marks) What are the typical latitudes between which carbonate banks form?

Section 6 – Siliciclastic Traps (20 Marks)

Q6-1 (10 marks) Draw an idealized profile for a normally prograding wave-dominated delta, and a plan view map of the delta. Include labels of depositional environments, a scale, and expected grain size on both the profile and map.

Q6-2 (2 marks) Draw a graph of grain size on the x-axis, and permeability on the y-axis, and use a line to depict the relation between these two parameters. Add a second line for porosity.

Q6-3 (8 marks) What diagenetic processes do sandstones undergo with burial? Indicate how these processes impact porosity and permeability.