

**ES486 Petroleum Geology
Mid-Term Exam Study Guide
Winter 2023**

Exam Format: The midterm exam will occur on Tuesday Feb. 14, 2023, worth a total of 100 points. Exam questions will be comprised of multiple choice, true/false and short answer-fill in blank; along with short and long answer essay, and lab-style problem solving. Two-Part Exam; Part 1 - Closed Book, qualitative exam questions, short answer essay – terms and definitions, draw sketches, long answer essay – “compare and contrast”, “discuss”, “explain”. Part 2, Open Book, lab-style problem solving, you will be able to use all of your class resources to solve math-based, lab-style problems.

Exam Logistics: In-person exam, NS218, no time limit, but scheduled for a 2-hour block. Additional testing accommodations are possible by prior arrangement with the professor.

Study Tips

- go through the web site, look at the figures and slide shows, compare to notes
 - review the video resources and exercise review sheets; check the lab answer keys for review
 - review textbook summary questions / answers
 - use study guide in combination with notes
 - go back through the in class / lab exercises, make sure you can work the math / units
 - spend a couple days studying, the exam will be essay and there is much material.
 - don't wait until the last minute!
 - carefully go through the notes, some of the material we briefly discussed, but did not spend much time on in class... but the notes will give you the detail
 - finish all your lab exercises and assignments before taking the exam!!! Lab questions will appear.
 - Exam format: Part 1. Closed book short answer / essay. Part 2. Open-book lab-style problem solving.
- NOTE: I would spend a minimum of 5 hours studying for this exam if I wanted to do well.**

Exam Study Resources (Readings and Class Notes from Weeks 1 through 5)

- Text Reading: Chapter 1 – Introduction
https://people.wou.edu/~taylors/es486_petro/text/Ch1_intro.pdf
- Class Notes 1. Introduction to Petroleum Geology
https://people.wou.edu/~taylors/es486_petro/1_Introduction.pdf
- Class Notes 2. Overview of Basic Physical Principles
https://people.wou.edu/~taylors/es486_petro/physrevw.pdf
- Class Notes 3. Introduction to the Earth System
https://people.wou.edu/~taylors/es486_petro/Intro_Earth_System_Science.pdf
- Text Reading: Chapter 2 - Properties of Petroleum
https://people.wou.edu/~taylors/es486_petro/text/Ch2_properties.pdf
- Text Reading: Sedimentary Rocks
https://people.wou.edu/~taylors/es486_petro/text/Sed_Rocks_Review.pdf
- Class Notes 4. Review of Sedimentary Rocks
https://people.wou.edu/~taylors/es486_petro/2_sedimentary_rock_review.pdf
- Class Notes 5. Overview of Stratigraphy and Depositional Systems
https://people.wou.edu/~taylors/es486_petro/3_Overview_Stratigraphy_Depositional_Systems.pdf
- Class Notes 6. Reservoir Fluids: Properties of Formation Water, Oil and Gas
https://people.wou.edu/~taylors/es486_petro/4_Reservoir_Fluids.pdf
- 6A. Physical Principles in Fluid Environments
https://people.wou.edu/~taylors/es486_petro/4A_Physical_Principles_Fluids.pdf
- Text Reading: Ch. 4 - Subsurface Environments
https://people.wou.edu/~taylors/es486_petro/text/Ch4_Subsurface.pdf
- Class Notes 7. Reservoir Fluids: Properties of Formation Water, Oil and Gas

https://people.wou.edu/~taylor/es486_petro/4_Reservoir_Fluids.pdf

- Text Reading: Ch. 5 - Petroleum Generation

https://people.wou.edu/~taylor/es486_petro/text/Ch5_generation.pdf

- Class Notes 8. Source Rocks: Generation and Migration of Petroleum

https://people.wou.edu/~taylor/es486_petro/5_source_rocks_generation_petroleum.pdf

- ~~Text Reading: Ch. 6 - Reservoirs~~

https://people.wou.edu/~taylor/es486_petro/text/Ch6_reservoir.pdf

- ~~Class Notes 9. Reservoir Properties~~

https://people.wou.edu/~taylor/es486_petro/6_Reservoir_Characterization.pdf

Review Questions from Homework Assignments:

- Task 2-1. Reading Review Questions - Ch. 2 Petroleum Properties
- Task 2-2. Video Review Questions: Earth Revealed Introduction to Sedimentary Rocks
- Task 2-3. Key Word Search Assignment: Overview of Sedimentary Rocks, Stratigraphy, Basins
- Task 3-1. Reading Review Questions Chapter 3 Subsurface
- Task 3-2. Video Review Questions Earth Revealed Living with Earth
- Task 3-4. Lecture Review Questions Univ. of Delft Carbon Cycle
- Task 4-1. Reading Review Questions: Chapter 5 Petroleum Generation and Migration
- Task 4-4. Lecture Review Questions Univ. of Delft: Oil and Gas Composition
- ~~Task 5-1. Reading Review Questions: Chapter 6 Reservoirs~~
- Task 5-2. Video Review Exercise: Earth Revealed Geologic Time
- Task 5-3. Lecture Review Questions Univ. of Delft: Oil Migration from Source to Sink
- Task 5-5. Reading Review Questions: Key Terms in Stratigraphy and Lithologic Correlation

Lab Exercises

Task 1-3. Introduction to Quantitative Analysis Lab Exercise

Task 2-4. Introduction to Engineering Principles and Rock Properties (Complete the following questions Q 1,3,4,5,7,9, 11, 21)

Task 3-3. Sedimentary Rocks Review Lab Exercise

Task 4-2. Fluid Pressure Exercise

~~Task 4-3. Ideal Gas Law Exercise~~

Task 5-4. Lab Exercise: Geologic Time

Review Selley “Essentials of Petroleum Geology” Introductory Text Chapters;

Chapter 1 Introduction;

“Creekology”

Anticline Theory

Five Conditions of Petroleum Accumulation

Source

Reservoir

Trap and seal

Timing

Preservation

Geology and Petroleum

Biology and Petroleum

Exploration vs. Production

Drakes Well, Titusville PA

Inert gas

Methane-ethane-propane

Helium

Carbon dioxide

Gas hydrates

Crude Oil

API Gravity

Paraffins-Napthenes-Aromatics-

Asphaltenes

“Cracking” Distillation

Sweet crude-sour crude

Chapter 4 Subsurface

Environment

Subsurface water

Connate-meteoric-juvenile water

Eh – Ph

Concentration

ppt, ppm, ppb

Brine water

Salinity

Total dissolved solids

Subsurface temperatures

Geothermal gradient

Bottom hole temperature

Thermal conductivity

Porosity / compaction

Formation temperatures

Subsurface pressures

Hydrostatic pressure

Lithostatic pressure

Oil-water contact

Pressure gradient

Artesian pressure

Structural pressure

Chapter 2 Properties;

Hydrocarbon gases

Natural gases

Organic matter

Key Words from Notes and Readings

(Web links provided below)

Introduction

https://people.wou.edu/~taylors/es486_petro/1_Introduction.pdf

hydrocarbons

phases: solid-liquid-gas

crude oil

natural gas

kerogen

gas hydrate

tars and resins

sedimentary basin

biogenic sediment

geologic time

thermal maturity

source rock/sediement

reservoir

seals, cap rock

trap

Conditions for Petroleum

Biogenic sediments

Source Rock

Thermogenic Maturation

Reservoir-Seal-Trap

Dry gas/ wet gas

Sweet vs. sour crude

Inert gases

Light Oil vs. Heavy Oil

Hydrocarbon composition Wt%

Paraffin

Napthene

Aromatics

Asphaltenes

Crude Distillates

Petroleum Engineering

Chemical Engineering

“Cracking”

Exploration-Production-

Refining-Marketing

Historical Perspectives on Oil

Drakes Well

Basic Principles Intro to Earth System

https://people.wou.edu/~taylors/es486_petro/Intro_Earth_System_Science.pdf

Earth System Science

Environmental Spheres

Atmosphere

Biosphere

Lithosphere

Hydrosphere

Lithosphere-Tectonic Plates

Geothermal-Gravity-Solar

Matter-Energy-Force

Kinetic Energy

Potential Energy

Open System-Closed System

Transfer of Mass

Transfer of Heat

Mass-Energy-Heat Flux

Hydrologic Cycle

Carbon Cycle

Rock Cycle

Tectonic Cycle

Physical Principles

https://people.wou.edu/~taylors/es486_petro/4A_Physical_Principles_Fluids.pdf

Mass-Length-Time-
Temperature
Force-Energy-Work
Motion-Velocity-Acceleration
Acceleration due to Gravity
Pressure

Power
Density
Weight Density = Specific
Weight
Viscosity
Heat-solid-liquid-gas
Density-Buoyancy
Temperature-Density Relations
Newtons-Joules-Pascals-Watts

Periodic Chart
Atomic Model
Neutrons-Protons-Electrons
Atomic Number
Atomic Mass
Isotope
Formula Weight
Mole

Review of Sedimentary Rocks

https://people.wou.edu/~taylors/es486_petro/2_sedimentary_rock_review.pdf

weathering
sediment
sediment transport
sediment burial
lithification
fossil
erosion
lithification
compaction
cementation
Sed. Rock types
 detrital
 biochemical
 chemical
sediment size fractions
 gravel

sand
silt
clay
grain shape
grain sorting
rock types
 sandstone
 conglomerate
 shale
 limestone
 evaporites
crystalline vs. microcrystalline
 coal
clastic / nonclastic
 marine
 nonmarine
 fluvial
 lacustrine
 glacial

Sedimentary Features
sedimentary structures
methods of transport
bedload
suspension
dissolved load
cross-stratification
graded bedding
reverse grading
normal grading
asymmetric ripples
symmetric ripples
flute casts
cast vs. mold
mudcracks
raindrop imprints
paleocurrents

Overview of Stratigraphy and Depositional Systems

https://people.wou.edu/~taylors/es486_petro/3_Overview_Stratigraphy_Depositional_Systems.pdf

Geologic time / Earth History
Age of Earth
Stratigraphy
Stratigraphic Record
Geologic Column / Time
 PreCambrian Era
 Archeozoic
 Proterozoic
 Paleozoic Era

Cambrian
Ordovician
Silurian
Devonian
Mississippian
Pennsylvanian
Permian
Mesozoic Era
 Triassic
 Jurassic
 Cretaceous
Cenozoic Era
 Tertiary
 Quaternary

Law of Original Horizontality
Law of Superposition
Law of Uniformitarianism
Law of Cross-Cutting Relations
Law of Faunal Succession
Walthers Law
Relative Geologic Dating
Absolute (numerical) Dating
Half Life
Parent-Daughter Isotopes
Radioactive decay
Horizontal/vertical bed relations
Dike-Sill-Fault
Lithostratigraphy

Biostratigraphy
Seismic Stratigraphy
Index Fossils
Unconformity
Angular Unconformity
Nonconformity
Conformable Strata
Interfingering Strata
Diastem
Lacuna
Paraconformity

Transgression-Regression
Onlap-Offlap
Eustacy
Sedimentary Basins
Facies
Formation
Member
Bed
Marine-NonMarine
Fluvial
Lacustrine

Deltaic
Littoral
Beach-Barrier
Lagoonal-Estuarine
Tidal Flat
Shelf
Slope
Abyssal Plain
Reef

Subsurface Fluids and Conditions

https://people.wou.edu/~taylors/es486_petro/4_Reservoir_Fluids.pdf

Water-Oil-Gas
Connate-Meteoric-Juvenile
Fluid Density-Buoyancy
Brines
Formation Water
Salinity-Concentration-Total
Dissolved Solids
Mass Percent-PPT-PPM-PPB
Solute-solvent
Crude Oil
C-H ratios

Parrafin-Napthene-Aromatics
Asphaltine
Barrels- bbl
Example Parrafin compounds
Example Napthenes-Aromatics
Molecular models
Oil Composition
Density-API Gravity Index
Viscosity-Temperature
Temperature-Volume-Density
Heat Content (BTU, Calorie)
Natural Gas
Dissolved vs. Free
“inflated oil”
Ideal Gas Law

Hydrocarbon Properties

http://www.wou.edu/las/physci/taylor/es486_petro/Hydrocarbon_Properties_Heat_Density_Viscosity.pptx

Heat-Energy
Calorie
Joule
BTU
Thermal heat value
Density-specific gravity
API gravity index
Viscosity
Volume – bbl = barrel = 42 gal

Subsurface Temperature and Pressure

http://www.wou.edu/las/physci/taylor/es486_petro/4B_Subsurface_Temperature_and_Pressure.pdf

Heat-Energy
Heat flux
Heat flow

Geothermal gradients
Thermal conductivity
Pressure
Overburden pressure
Lithostatic pressure
Hydrostatic pressure
Pressure gradients

Formation temperature
Formation pressure
Bottom hole temperature
Bottom hole pressure
Thermal maturation

Chapter 5 Generation & Migration

https://people.wou.edu/~taylors/es486_petro/5_source_rocks_generation_petroleum.pdf

Organic vs. Inorganic Source
Mantle hydrocarbon
Meteorite hydrocarbon
Igneous hydrocarbon
Sedimentary hydrocarbon
Carbon cycle
Photosynthesis
Bacterial decay

Protein-carbohydrate-lignin-lipids
Plant vs. animal carbon
Biomass production
Organic preservation
Organic productivity Marine
Productivity NonMarine
kerogen
Bitumen
Diagenesis
Type I-II-III Kerogen
Maturation

Catagenesis
Metagenesis
Paleothermometry
Vitrinite Reflectance
Biogenic gas production
Thermogenic gas production
Primary Migration
Secondary Migration
Overpressure/microfractures
Oil Expulsion

~~Reservoirs (Selley Chapter 6)~~

~~<https://people.wou.edu/~taylors/es486-petro/6-Reservoir-Characterization.pdf>~~

~~Porosity~~

~~Effective porosity~~

~~Total porosity~~

~~Primary porosity~~

~~Secondary porosity~~

~~Intergranular porosity~~

~~Fracture porosity~~

~~Solution porosity~~

~~“Vuggy Porosity”~~

~~Intercrystalline porosity~~

~~Cementation/compaction~~

~~Diagenesis~~

~~permeability~~

~~permeability vs. porosity vs.~~

~~lithology~~

~~Darcy’s Law~~

~~Millidarcy~~

~~100 md reservoir threshold~~

~~Viscosity~~

~~Permeameter~~

~~Horizontal vs. vertical~~

~~permeability~~

~~Homogenous vs. heterogeneous~~

~~Anisotropic vs. Isotropic~~

~~Artesian Reservoirs (gushers)~~

~~Texture vs. Permeability vs.~~

~~Porosity~~

~~Grain Shape-Sorting-Grain Size~~

~~Clay/shale vs. Sand/Sandstone~~

~~Grain packing; grain fabric~~

~~Sandstone/Limestone~~

~~Reservoirs~~

~~Shale/Mudstone Seals~~

~~Diagenesis effects on Reservoir~~

~~Clay alteration~~

~~Authigenic Clay~~

~~Feldspar degradation~~

~~Porosity loss vs. compaction~~

~~Cementation vs. porosity~~

~~Depth compaction curves~~

~~Clay diagenesis / dewatering~~

~~Carbonate diagenesis~~

~~Dolomitization~~

~~Calcite-Dolomite~~

~~Transformation~~

~~Reservoir shape / continuity~~

~~Sheet vs. ribbon vs. pod~~

Quantitative / Lab Skills

Quantitative Methods

Perform basic unit conversions-unit algebra-solve quantitative word problems

Process Rate Calculations

calculate potential energy, kinetic energy, force, weight, stress

pressure-depth calculations

application of idea gas law to subsurface gas accumulations

calculation of basic engineering properties of rocks

porosity-density-specific weight

Sedimentary Rocks

what about the three diff. types of sed. rocks?

Can you estimate: grainsize? sorting? grading? angularity?

What about basic paleocurrent directions? How can you tell which way the fluid was moving when the sediment was deposited?

What about recognizing some basic sedimentary structures?

Associating a specific rock type to a possible sedimentary environment?

How does transport energy relate to grain size of deposits? (e.g. would you find boulders in the deep ocean?)

What are the basic marine and nonmarine sedimentary environments?

What are sedimentary structures and how are they used to reconstruct sedimentary environments?

What type of environment do the various sed. rock types form? e.g. sandstone, conglomerate, evaporites, coal, mudcracks, limestone, etc. where would these rocks form at the earth's surface?

Review the lab answer keys on class web site!

Big Concepts for Long-Answer Essay Questions

What are the primary types of hydrocarbons?

What are the criteria necessary for the generation and accumulation of hydrocarbons in subsurface?

What compounds are petroleum and natural gas composed of? What are the basic carbon families and their general molecular compositions? What is the process necessary to find and produce petroleum-related products for industry? What is the basic refining process? How does transport energy relate to grain size of deposits? (e.g. would you find boulders in the deep ocean?)

What are the fundamental energy sources of the earth system? How do force-energy-pressure relate to the subsurface environment? What are the temperature and pressure conditions like in the subsurface environment?

What are the fundamental components of the Earth System?

How do the study of sedimentology and stratigraphy relate to petroleum geology?

What are the basic laws and principles of stratigraphy used to analyze sedimentary rocks?

What are the basic marine and nonmarine sedimentary environments?

What are sedimentary structures and how are they used to reconstruct sedimentary environments?

What type of environment do the various sed. rock types form? e.g. sandstone, conglomerate, evaporites, coal, mudcracks, limestone, etc. where would these rocks form at the earth's surface?

How do sediments accumulate over time? How is time recorded in the rock record?

What are the primary fluids contained in the subsurface environment? Relative abundance and composition of each? What is the chemical composition of formation water? Crude oil? Natural gas?

What are the key properties used to characterize petroleum and natural gas?

How is petroleum generated? What are the geologic conditions necessary? Discuss the global carbon cycle in the context of petroleum geology. What are the sources of organic materials in petroleum? Chemical composition? What are the steps in petroleum generation? The thermal maturation process?

What are the essential properties for Reservoir rocks? What types of sedimentary rocks are associated with reservoirs?