**Lab 1. Source rock**

Student No.: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Student Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Student No.: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Student Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Hand-in deadline: **11th April 2019**

Graded lab can be picked up at the lab session on **25th April 2019.**

 Grade: \_\_\_\_\_ / 15 = \_\_\_\_\_

**Problem 1 (3 points)**

1.1 Define key requirements for organic matter to be preserved in the sediments. (1 point)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1.2 Define one depositional environment example at continent where you have the right conditions for preservation of organic matter? (1 point)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1.3 What type of organic matter/kerogen would you expect to be preserved in this environment? (1 point)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Problem 2 (5 points)**

2.1 Define the type of organic matter for particular kerogen type below. Also define the hydrocarbon type that most likely generate by those kerogen type. (3 points)

Type I: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Expected hydrocarbon type: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Type II: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Expected hydrocarbon type: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Type III: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Expected hydrocarbon type: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2.2 Describe briefly 2 methods of measuring the quality of source rock: (2 points)

Method 1: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Method 2: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Problem 3 ( 7points)**

Hydrocarbon generation is a rate-controlled process referred to as catagenesis or maturation.

The essential control of petroleum generation is a time-temperature relation based on the Arrhenius equation (which basically says that the rate of chemical reaction doubles for every increasing 10degC increment). Considering the generation of oil as a chemical reaction governed by this control, the amount of oil from a reaction varies linearly with time and exponentially with temperature. For example, Cenozoic source rocks need a greater temperature (~100°C) than Mesozoic source rocks (~65°C) for hydrocarbon generation. In 1971, N.V. Lopatin calculated the thermal maturity of organic matter in sediments by devising a time-temperature index based upon the Arrhenius equation (TTIARR).

3.1 Use the two burial-history curves (for formations A and B in Figure 1) and the Figures 2 and Figure 3 to fill the Tables 1 and Table 2 for Shale A and Shale B. Apply the following procedure: (3 points)

3.1.1 Obtain exposure time ($t\_{n+1}-t\_{n}$) for each temperature range from the burial curve. (1 point)

3.1.2 Use Figure 2 to obtain TTIARR for each temperature range from the burial curve. (1 point)

3.1.3 Calculate Σ TTIARR and the percentage of oil and gas generated (Figure 3) and locate the oil window. (1 point)

**Table 1.** Shale A

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Temperature (°C) | Exposure time(Mya) | TTIARR | ΣTTIARR | Oil and Gas( %) | Window |
| 40-50 |  |  |  |  |  |
| 50-60 |  |  |  |  |  |
| 60-70 |  |  |  |  |  |
| 70-80 |  |  |  |  |  |
| 80-90 |  |  |  |  |  |
| 90-100 |  |  |  |  |  |
| 100-110 |  |  |  |  |  |
| 110-120 |  |  |  |  |  |
| 120-130 |  |  |  |  |  |

**Table 2.** Shale B

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Temperature (°C) | Exposure time(Mya) | TTIARR | ΣTTIARR | Oil and Gas( %) | Window |
| 40-50 |  |  |  |  |  |
| 50-60 |  |  |  |  |  |
| 60-70 |  |  |  |  |  |
| 70-80 |  |  |  |  |  |
| 80-90 |  |  |  |  |  |
| 90-100 |  |  |  |  |  |
| 100-110 |  |  |  |  |  |
| 110-120 |  |  |  |  |  |



**Figure 1.** Burial curve for two source rock formations; A and B



**Figure 2.** Relationships among time, temperature and TTIARR for type IIA kerogen



**Figure 3**. Graph showing the relationship between Σ TTIARR and percentage of oil and gas generated based on the following equation:

$$X\%=(1-exp⁡(-TTI\_{ARR}/100))×100$$

The time-temperature index ($TTI\_{ARR}$) can be defined very simply as the “amount of heat build-up” of the source rock exposed to a specific temperature increment as a function of its exposure time.

For a constant temperature:

$$TTI\_{ARR} = ((t\_{n+1}-t\_{n})A×exp(-E/RT))×100$$

$t\_{n+1}-t\_{n}$ = exposure time, E = activation energy, R = ideal gas constant

3.2 Assuming that shales A and B have the same characteristics other than different burial histories, answer the questions: (4 points)

3.2.1 At 50 million years before present, what oil percentage had shale A generated? How about shale B? (2 points)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3.2.2 When and at what approximate depth had shales A and B generated 50% of the total potential oil? (2 points)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_