PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

MAKE-UP EXAMINATION-JAN 2023

Course Code: PET2002

Course Name: Fundamentals of Geophysical Logging Techniques

Program   : B.Tech.

Date: 25-JAN-2023

Time: 01:00 PM to 04:00 PM

Max Marks: 100

Weightage: 50%

Instructions:

(i) Read the all questions carefully and answer accordingly.
(ii) Question paper consists of 3 parts.
(iii) All the questions are compulsory.

Part A [Memory Recall Questions]

Answer all the questions. Each question carries EIGHT marks.   (4Qx8M = 32M)

1: Choose the correct answer.

(a) The depth of invasion depends on _____.
   (i) porosity
   (ii) conductivity
   (iii) porosity and permeability
   (iv) resistivity

(b) During drilling, mud-cake build-up takes place wherever the mud-filtrate _____.
   (i) filtrates
   (ii) infiltrates
   (iii) enters
   (iv) none of (i), (ii) and (iii)

(c) The equation $\emptyset = a * F^n$ is known as _____.
   (i) Porosity equation
   (ii) Permeability equation
   (iii) Archie's equation
   (iv) Tarzaghi's equation

(d) Which one is not considered as one of the functions of drilling mud?
   (i) bringing cuttings up to surface
   (ii) preventing flow of formation fluids
   (iii) preventing hole from collapsing outwards
   (iv) cooling the drill bit

(e) Borehole in gauge, most commonly observed in _____.
   (i) Shale & shaly formations
   (ii) Sandy formations
   (iii) Silty formations
   (iv) Hard and compact formations

(f) In the well log sheet Resistivity-Curves are plotted in the _____.
   (i) 1st track-linear scale
   (ii) 2nd rack-linear scale
   (iii) 3rd track-linear scale
   (iv) 2nd track-logarithmic scale

(g) What is the full form of MWD in logging?
   (i) Movement while drilling
   (ii) Measurement while drilling
   (iii) Mud weight decreasing
   (iv) None of the above

(h) Common value of matrix-density (g/cm3) of limestone is _____.
   (i) 2.98   (ii) 2.87
   (iii) 2.65   (iv) 2.71

2: Match the information in Column A and Column B.

Column A	Column B
(a) Formation Factor (F) is expressed as _____.	(i) Archie's Equation
(b) Logging cable fulfills three functions; (a) running-in and pulling out the tool, (b) depth measurement, and (c) _____.	(ii) R_0/R_w
(c) Relation between Porosity and Water Saturation for the Invaded Zone can be expressed as _____.	(iii) conductivity of current through drilling mud
(d) The volume close to the borehole wall in which some or all of the moveable fluids have been displaced by mud filtrate is known as _____ Zone.	(iv) electrical interface between the downhole logging tool and the surface processing and recording unit
(e) The relation of fluid saturation in the uninvaded zone to that in the near borehole invaded zone gives us the measure of _____.	(v) $\emptyset = ((a/S^{wn})*(R_{xo}/R_f))^{1/m}$
(f) First ever log was recorded by the company called _____.	(vi) $\emptyset = ((a/S_i^n)*(R_{mf}/R_i))^{1/m}$
(g) Shales have _____ gamma ray values.	(vii) Mud Displacement
(h) A salt-saturated mud, because of its high conductivity, will contribute a _____ borehole signal to the induction log.	(viii) Invaded
	(ix) movable hydrocarbon index
	(x) Schlumberger
	(xi) Halliburton
	(xii) high

3: Fill in the blank with appropriate single word.
   (a) Sonic logs also helps in interpretation for _____ determination and seismic to well tie.
   (b) The main use of Caliper tool is to determine borehole shape and _____.
   (c) Archie's equation does not give correct results in shaly sand since shale adds to the _____ of the formation.
   (d) The invasion process _____ the hydrocarbon saturation in the zone near the borehole in the hydrocarbon bearing permeable beds when drilled with water based mud.
   (e) The SP log will deflect to the _____ side in the clean water bearing sand compared to the shale when $R_{mf} > R_w$..
   (f) The Laterolog tools will work best in _____ mud.
   (g) The Sonic Δt _____ with the increase in shaliness of water bearing sandstone.
   (h) The main uses of _____ log are to dentify sand-shale zones in the formation.

4: (a) Discuss the purpose of RFT Tools. [4 Marks]
   (b) List down the applications of Cement Bond Log. [4 Marks]

Part B [Thought Provoking Questions]

Answer all the questions. Each question carries TEN marks.   **(4Qx10M = 40M)**

5: Due to the expense of obtaining core samples, typically only a few wells are cored. There are three types of logging tools that are used to estimate the amount of porosity in rock: the neutron, acoustic velocity (or sonic), and density tool. The neutron tool operates by bombarding the formation with high-energy neutrons and is sensitive mainly to the number of hydrogen atoms in a formation. The sonic or acoustic log measures the travel time of an elastic wave through the formation which derives the velocity of elastic waves through the formation. The density log measures electron density and transforms it into bulk density, porosity is calculated by assuming the matrix density and fluid density.

(a) Suppose the data for Density, Gamma Ray, and Resistivity logs are available. Will it be possible to determine porosity in absence of Neutron Porosity log from available log data? If yes, then write down the equation to be used for determining the porosity of the formation.

(b) Bulk density, matrix density, and fluid density are given as 2.50 g/cc, 2.87 g/cc, and 1 g/cc respectively for a formation. Is there any possibility to extract additional information about the same formation? If yes, then determine the additional information.

(c) Identify the appropriate chart from the list of charts (Charts 1 through 10) shared at the end and predict at least one additional information using the same chart and recorded values of bulk density, matrix density, and fluid density.   [2M + 4M + 4M]

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

6: Under some circumstances, the FDC (Compensated Formation Density) log and Litho-Density log must be corrected for borehole size, and the SNP (Sidewall Neutron Porosity) log must be corrected for mudcake thickness. The borehole diameter (d_h), formation density (ρ_b), mud density (ρ_m), SNP apparent porosity (ϕ_{SNP}), caliper log reading in the mudcake, and bit size are recorded as 14 in, 2.60 g/cc 1.50 g/cc, 15 p.u., 7⅝ inch, and 7⅞ inch respectively for a mud-filled borehole.

(a) List down the additional information that can be find out with the help of available data and the Chart No. 5 shared below.

(b) Determine the additional information that can be find out with the help of available data and the Chart No. 5-A and 5-C.   [2M + 8M]

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

7: (a) In log interpretation, the Bottom Hole Temperature (BHT) is taken as the maximum recorded temperature during a logging run or preferably the last of series of runs during the same operation. BHT is the temperature used for the interpretation of logs at total depth. If the BHT at 11000 ft is 200°F (Point A) in shared Chart 1, then list down the information that can be recorded from Point X marked in the same Chart. Submit Chart 1 for evaluation.

(b) The more you increase your concentration, the higher the amount of species that can contribute to conduction. Hence, resistance decreases with increasing concentration. If the resistivity of a water sample is 2 ohm-m at 40°C, then find NaCl concentration at 40°C from Chart 2. Suppose the NaCl concentration is kept constant at 150°C, then discuss the information that can be extracted additionally from the same Chart. Submit Chart 2 for evaluation.   [4M + 6M]

(C.O.No. 2) [Comprehension]

8: The Formation Resistivity Factor (F_R) is defined as the ratio of the resistivity of the rock saturated with brine (R_o) to the resistivity of the brine (R_w).

(a) Will it be possible to determine F_R for available porosity, cementation factor, and lithology coefficient as 3.6%, 1.6, and 1 respectively? If yes, then write down the formula and calculate F_R using the same formula. If no, then write down the process for determining F_R.

(b) Is it possible to determine F_R from any of the available charts (1 through 10)? If yes, then choose the correct chart and determine F_R by plotting the available data. If no, then explain any other method used to determine F_R. [5M + 5M]

(C.O.No. 2) [Comprehension]

Part C [Problem Solving Questions]

Answer the question. The question carries FOURTEEN marks. **(2Qx14M = 28M)**

9: Epithermal neutron detection with borehole-shielded detectors considerably reduces the environmental effects on the APS (Accelerator Porosity Sonde) response and simplifies their correction. The near-to-array porosity measurement (APLU in apparent limestone porosity units) and the near-to-far porosity measurement (FPLU in apparent limestone porosity units) require different mud weight and borehole size corrections, so there are individual sets of correction nomographs for each measurement. Formation temperature, pressure, and salinity effects are, however, the same on each measurement, so there is only one set of nomographs for these corrections. The formation salinity correction is dependent on the amount of salt (NaCl) in the formation. This is a function of both the salinity of fluid in the formation and its volume. The last part of the nomograph, therefore, applies to the correction of a multiplier proportional to the true porosity of the formation. For an openhole well, uncorrected limestone porosity, mud weight, borehole size, borehole temperature, pressure, and formation salinity are recorded as 25 p.u., 12 lbm/gal, 12 inch, 100°F, 2500 psi, and 150 kppm respectively.

(a) List down the corrections that can be determined from the data shared and the Chart No. 6.
(b) Determine corrected values for all the components listed above. [4M + 10M]

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

10: Cross plots are visual representations of the relationship between two or more variables, and they are used to visually identify or detect anomalies that could be interpreted as the presence of hydrocarbon or other fluids and lithologies.

(a) One of the earliest cross plots is the neutron porosity and bulk density cross plot. This cross plot is used in log analysis for the determination of porosity and lithology from neutron porosity and bulk density. Choose the correct chart from Charts 1 through 10 and identify the lithology based on the given well log data.

Sl. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Neutron Porosity (p.u.)	18	19	20	20	20	21	21	22	22	22	23	23	24	25	25
Bulk Density (g/cm³)	2.34	2.32	2.30	2.32	2.34	2.30	2.32	2.28	2.32	2.40	2.38	2.40	2.38	2.38	2.40

(b) A cross-plot of sonic transit time and bulk density can be used to identify lithology. Choose the correct chart from Charts 1 through 10 and identify the lithology based on the given well log data.

Sl. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sonic Transit Time (μsec/ft)	2.30	2.30	2.40	2.40	2.40	2.40	2.50	2.50	2.50	2.50	2.60	2.60	2.60	2.60	2.60
Bulk Density (g/cm³)	2.44	2.46	2.40	2.42	2.44	2.46	2.40	2.42	2.44	2.46	2.38	2.40	2.42	2.44	2.46

[7M + 7M]

(C.O.No. 5) [Application]

CHART 1: Related ANSWER should be written in the ANSWER-SCRIPT as well, otherwise the answer will not be evaluated.

Temperature gradient conversions: $1°F/100 ft = 1.823°C/100 m$
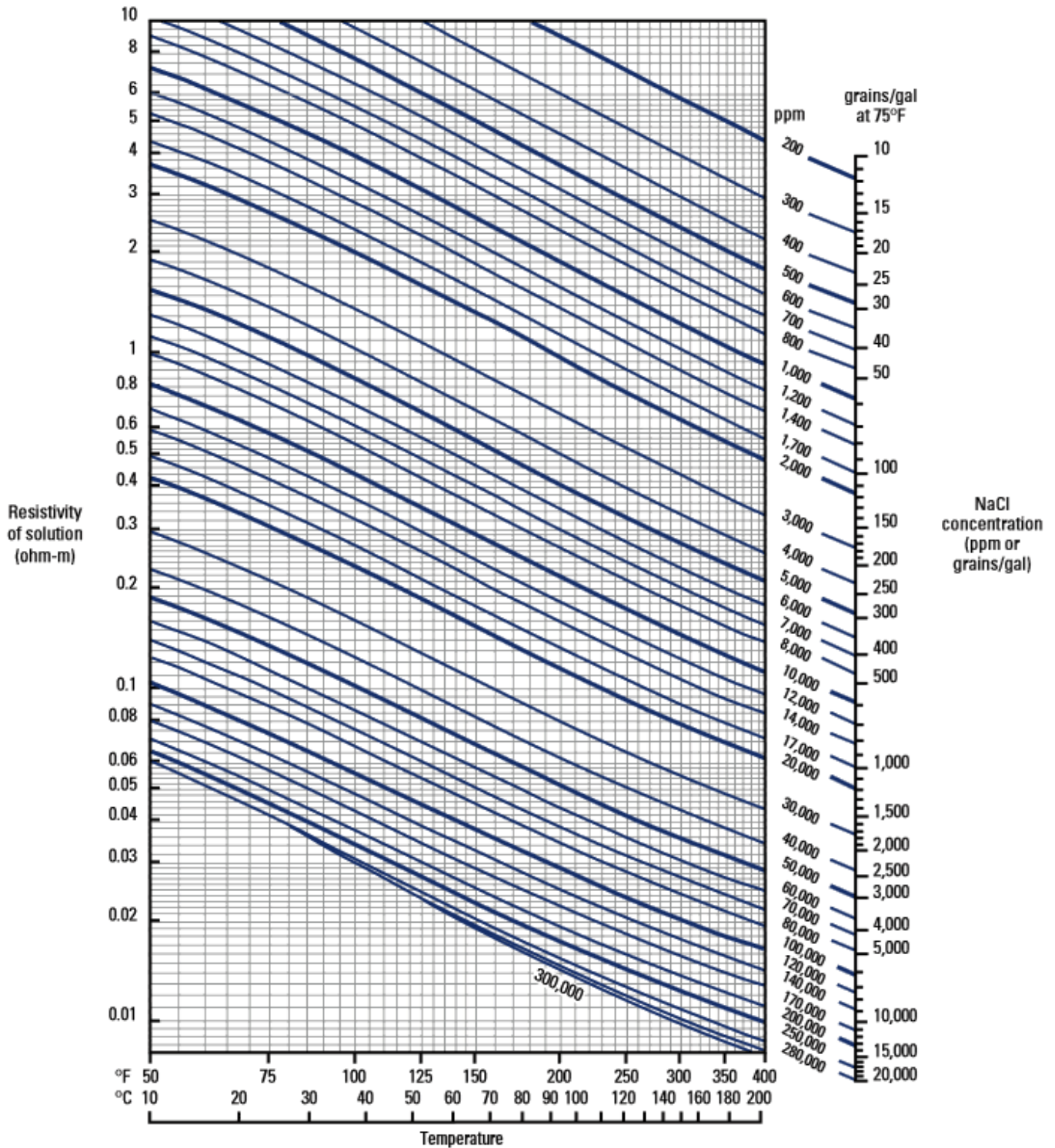$1°C/100 m = 0.5486°F/100 ft$
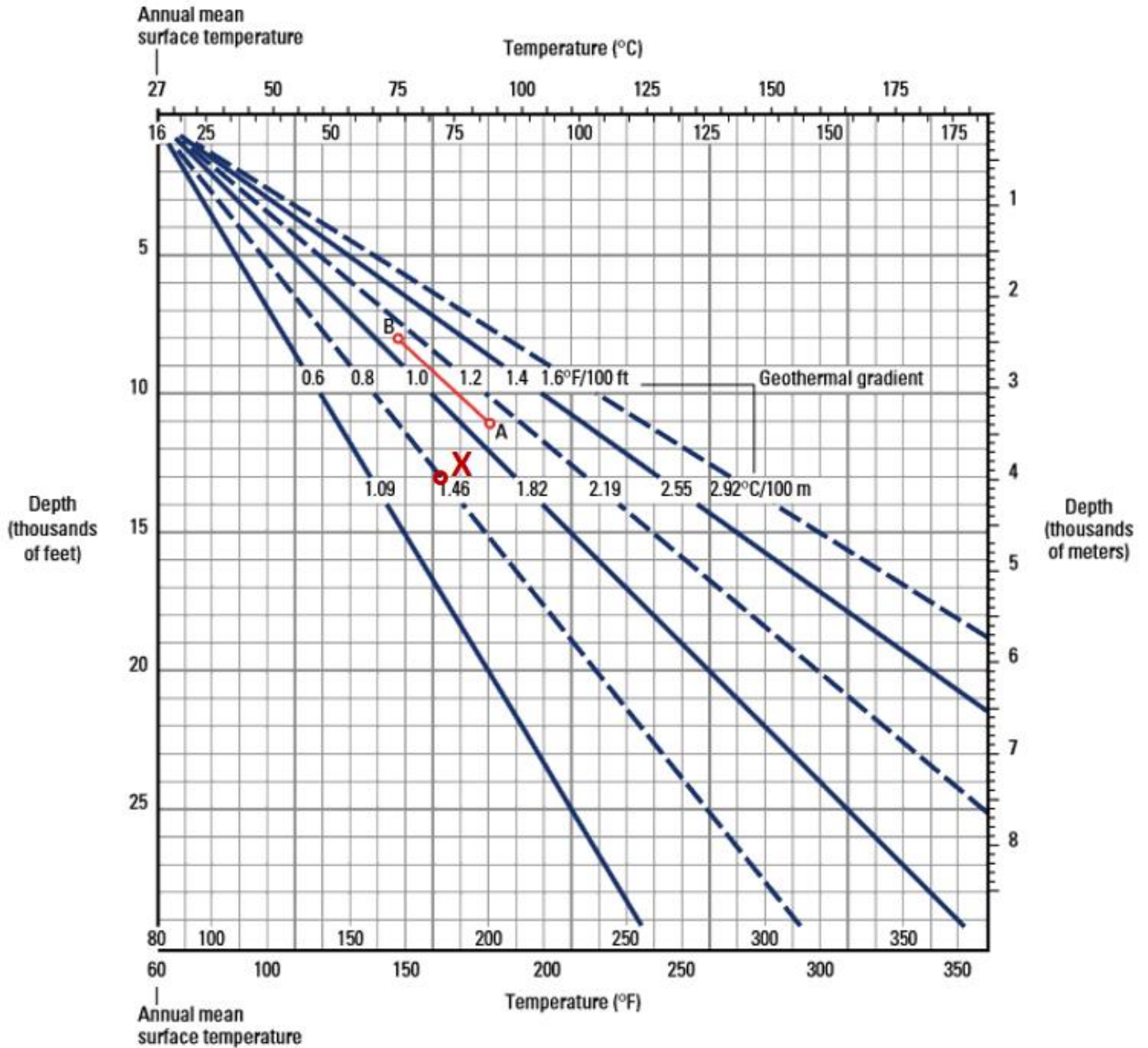
Calculations (if required) and Answer:

CHART 2: Related ANSWER should be written in the ANSWER-SCRIPT as well, otherwise the answer will not be evaluated.

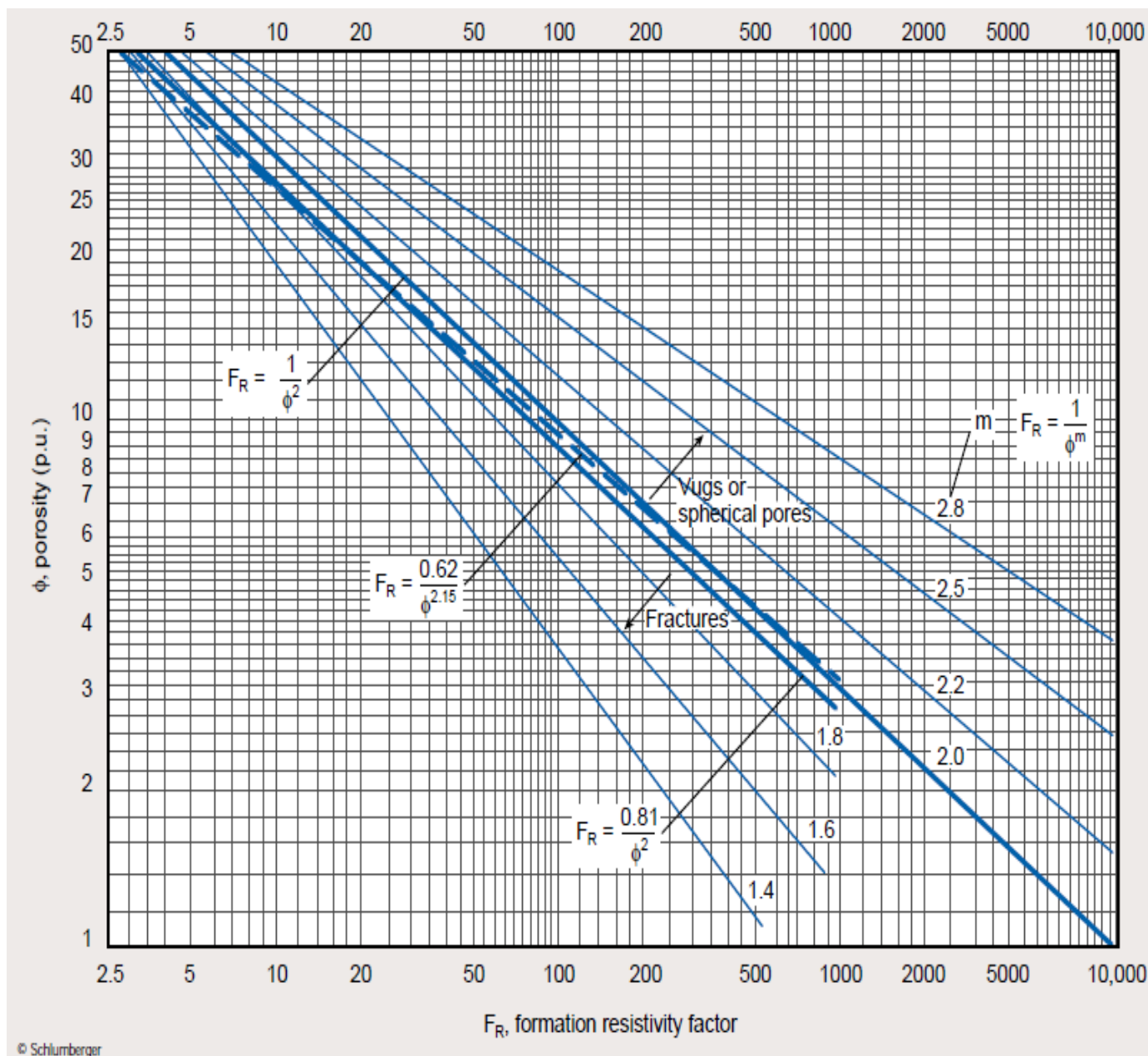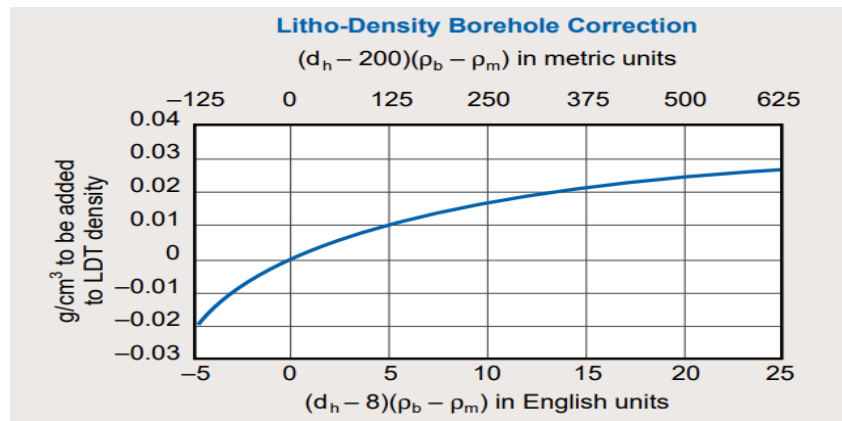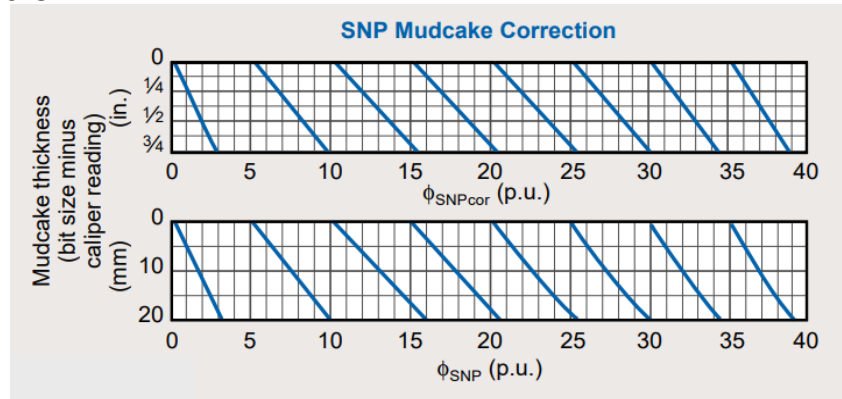Conversion approximated by $R_2 = R_1 [(T_1 + 6.77)/(T_2 + 6.77)]°F$ or $R_2 = R_1 [(T_1 + 21.5)/(T_2 + 21.5)]°C$

Calculations (if required) and Answer:

Answer To
Q _____

CHART 3: Related ANSWER should be written in the ANSWER-SCRIPT as well, otherwise the answer will not be evaluated.

© Schlumberger

Calculations (if required) and Answer:

CHART 4: Related ANSWER should be written in the ANSWER-SCRIPT as well, otherwise the answer will not be evaluated.
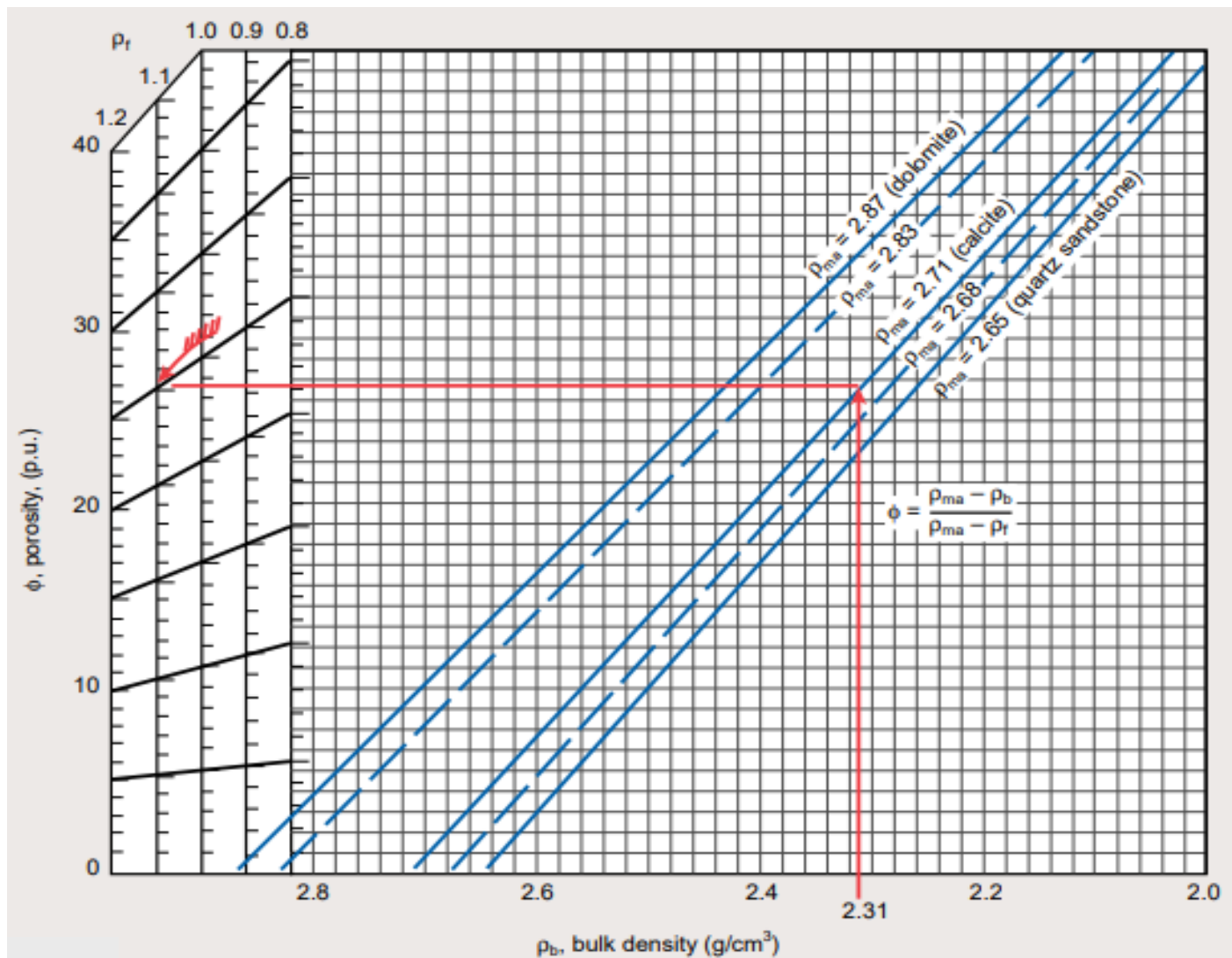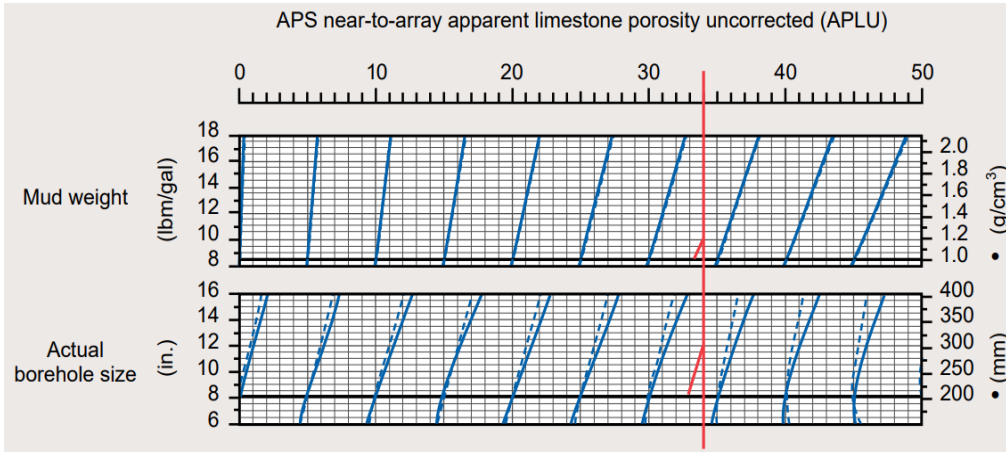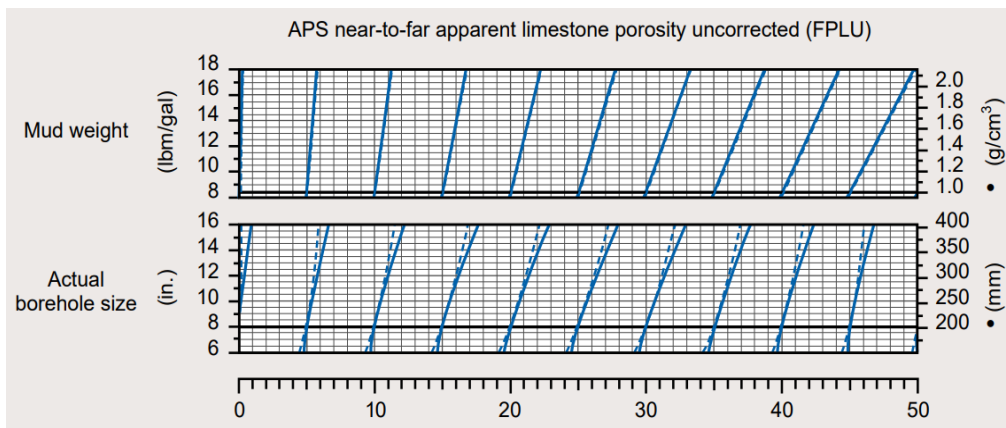

Calculations (if required) and Answer:

STUDENT NAME: _____

ROLL NO.: _____

CHART 5: Related ANSWER should be written in the ANSWER-SCRIPT as well, otherwise the answer
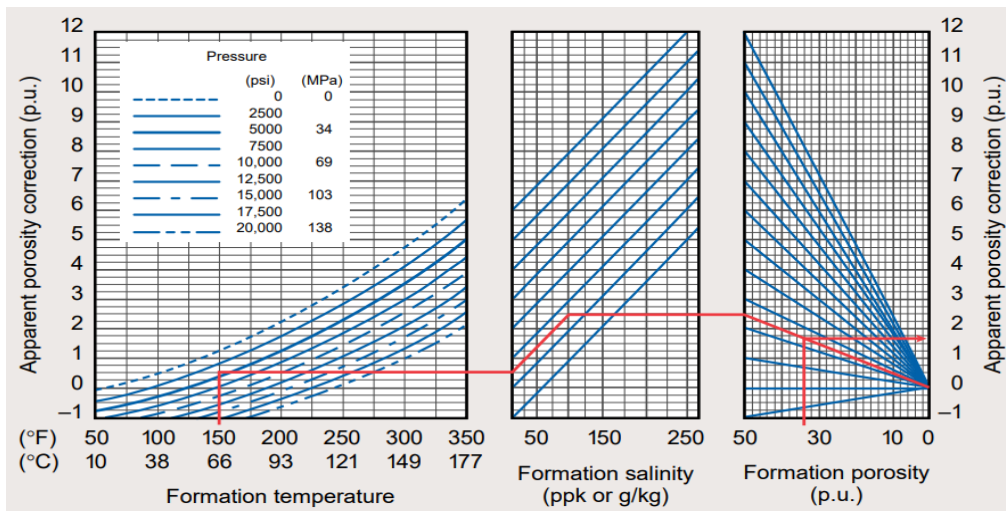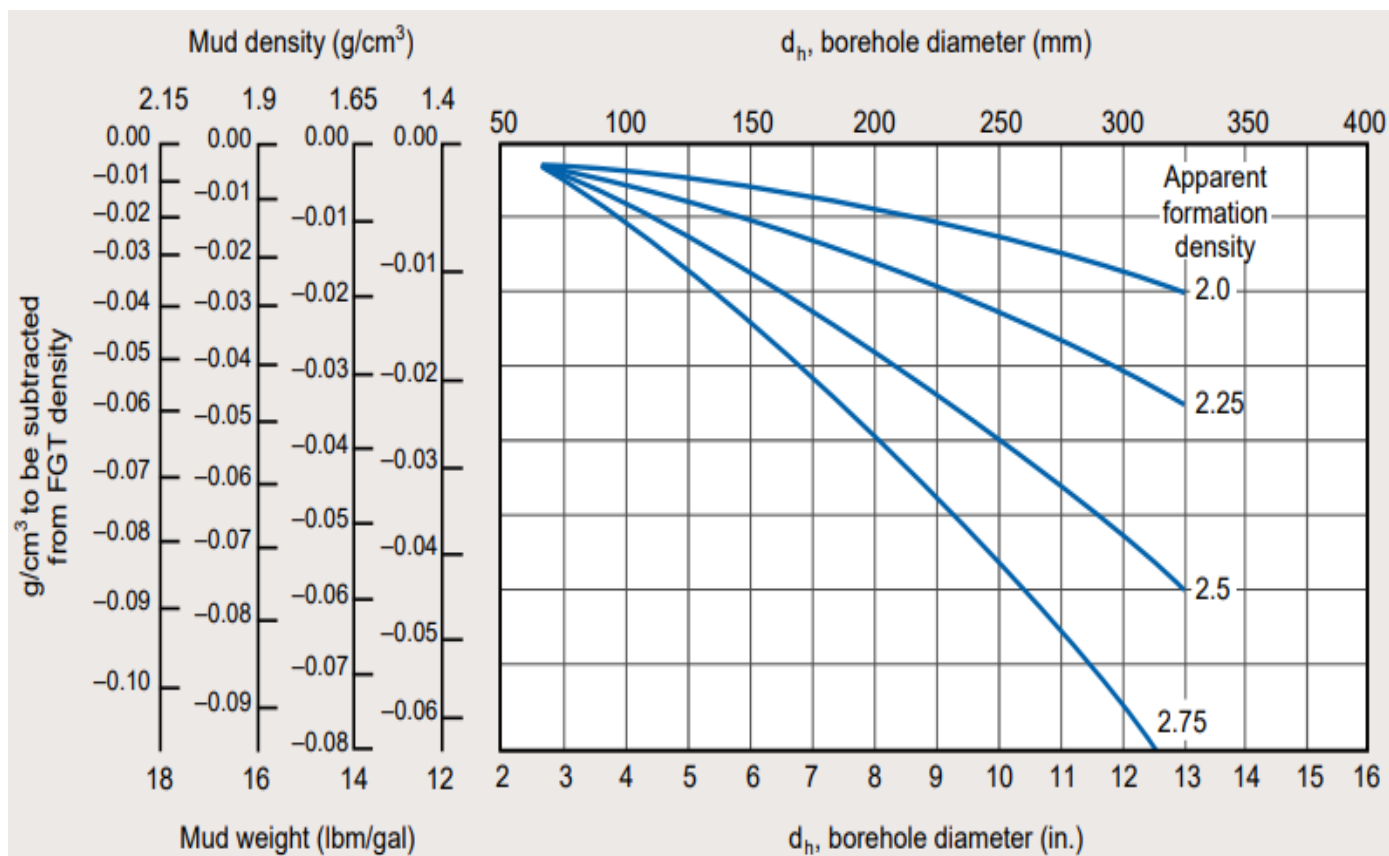will not be evaluated.

5-A
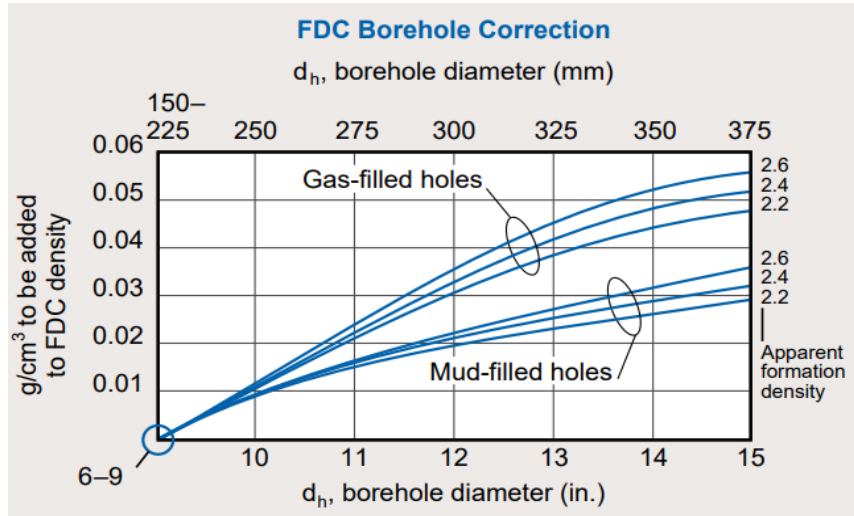
FDC Borehole Correction

d_h, borehole diameter (mm)

5-B

Litho-Density Borehole Correction

$(d_h - 200)(\rho_b - \rho_m)$ in metric units

$(d_h - 8)(\rho_b - \rho_m)$ in English units

5-C

SNP Mudcake Correction

ϕ_{SNPcor} (p.u.)

ϕ_{SNP} (p.u.)

Calculations (if required) and Answer:

CHART 6: Related ANSWER should be written in the ANSWER-SCRIPT as well, otherwise the answer will not be evaluated.

6-A

APS near-to-array apparent limestone porosity uncorrected (APLU)

6-B

APS near-to-far apparent limestone porosity uncorrected (FPLU)

6-C

Calculations (if required) and Answer:

CHART 7: Related ANSWER should be written in the ANSWER-SCRIPT as well, otherwise the answer will not be evaluated.
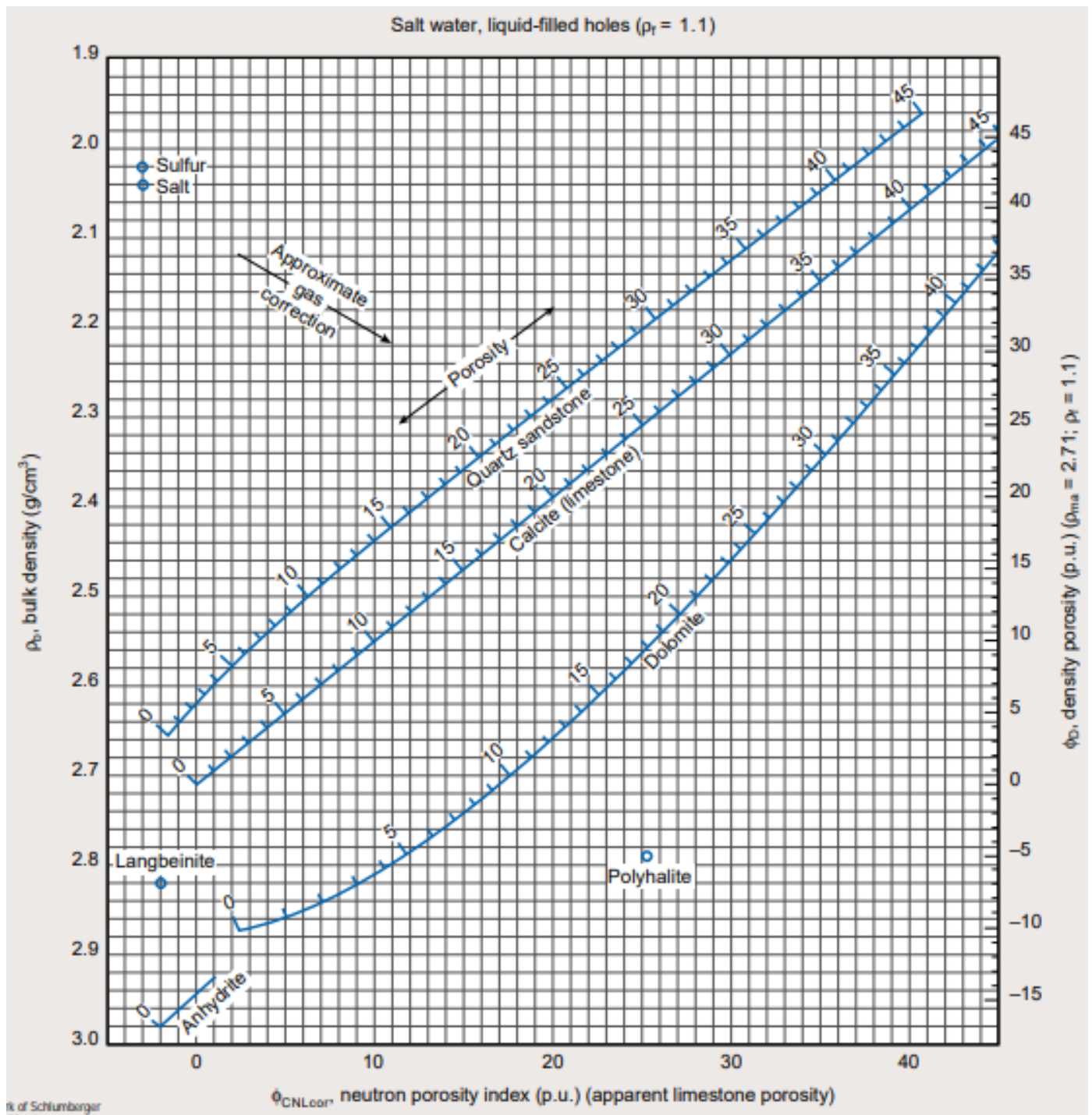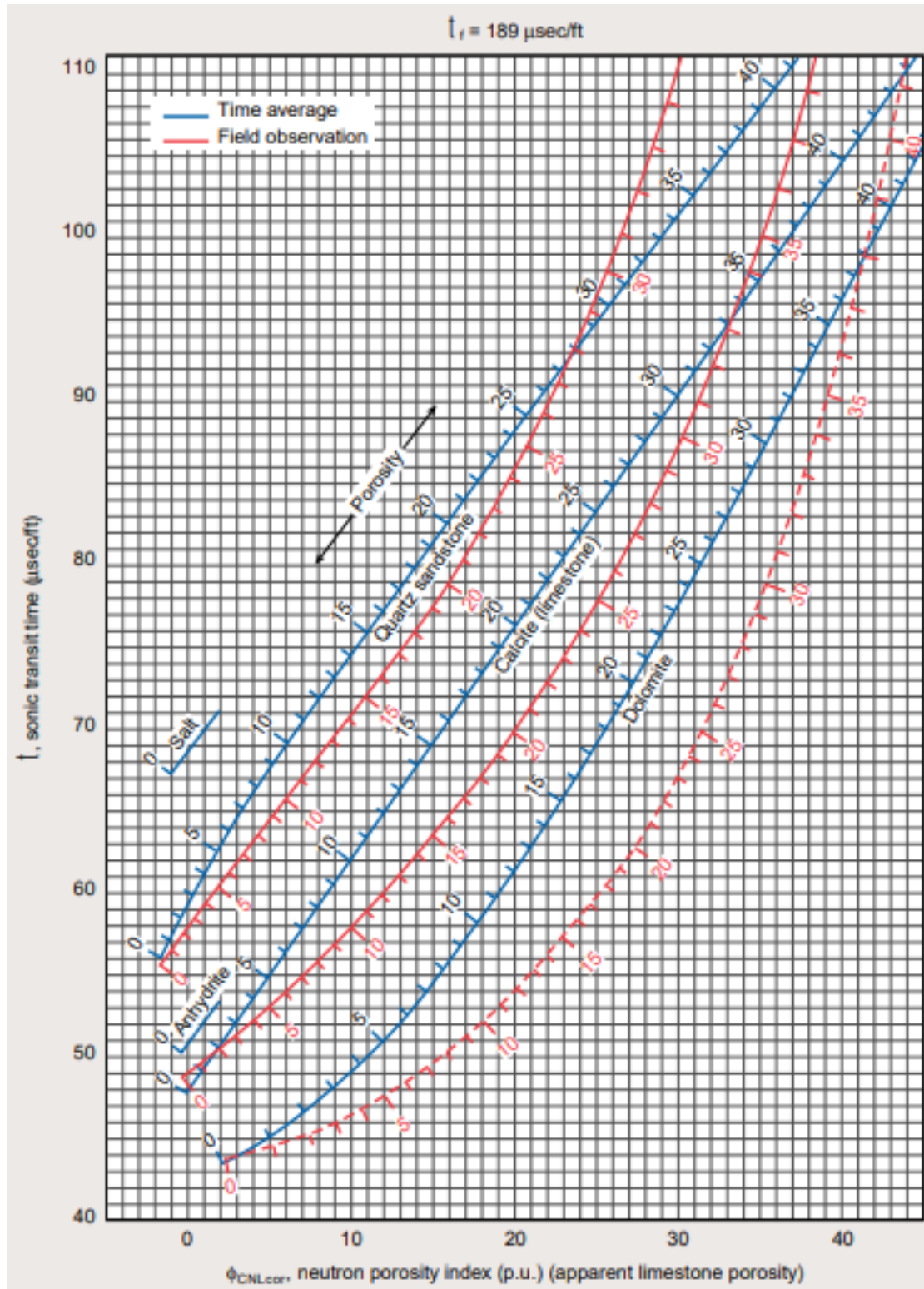

Calculations (if required) and Answer:

CHART 8: Related ANSWER should be written in the ANSWER-SCRIPT as well, otherwise the answer will not be evaluated.

Salt water, liquid-filled holes (ρ_f = 1.1)

Calculations (if required) and Answer:

CHART 9: Related ANSWER should be written in the ANSWER-SCRIPT as well, otherwise the answer will not be evaluated.
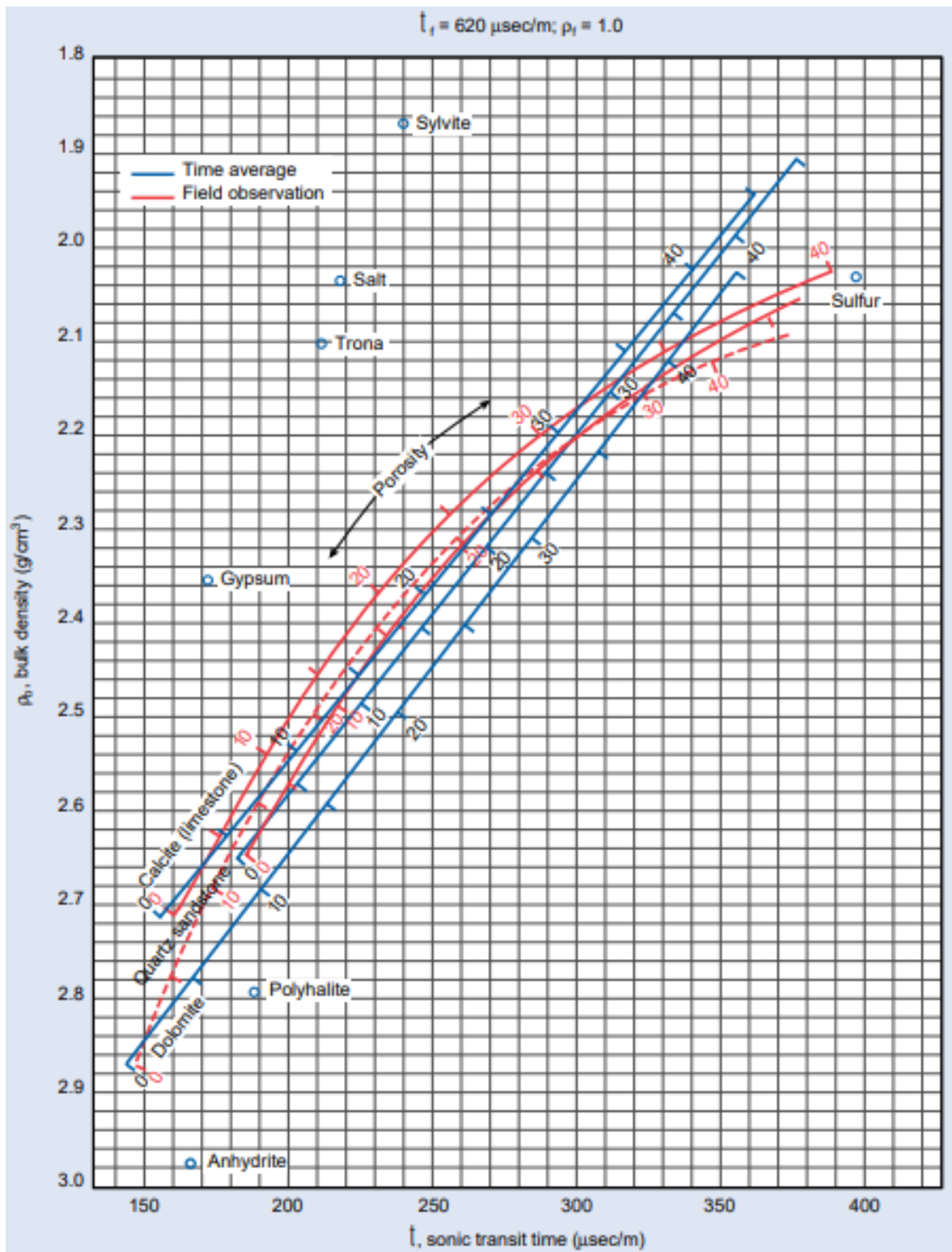

Calculations (if required) and Answer:

STUDENT NAME: _____

ROLL NO.: _____

CHART 10: Related ANSWER should be written in the ANSWER-SCRIPT as well, otherwise the answer will not be evaluated.

Calculations (if required) and Answer: