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FOREWORD

This Study Guide has been prepared to aid petroleum professionals studying for the SPE Petroleum Engineering Certification Program. The material includes a full sample exam that can be used to help prepare for the certification exam.

SPE certification has been discussed both within and outside the society for many years. Many petroleum engineers have not been required to be certified until the past few decades. The environmental and consumer era of the past few decades have given the public greater awareness of pollution, energy, and the need for more industry professionalism.

In 2004, The Society of Petroleum Engineers established a pilot program to provide a society-sponsored Petroleum Engineering Certification Program at the request of the membership.

ACKNOWLEDGMENTS

The SPE Petroleum Professional Certification Subcommittee gratefully acknowledges the contributions of the authors of *A Guide to Professional Engineering Licensure* and the SPE U.S. Engineering Registration Subcommittee and SPE Engineering Professionalism Committee for permission to use material from that book. The Subcommittee also recognizes past and present Committee members for their efforts in preparing this guide, with thanks to Gus Mistrot, P.E., Bing Wines, P.E., Charles Haynes, P.E., and William McCain, P.E., for their contributions to earlier editions of *A Guide to Professional Licensure for Petroleum Engineers*. Special thanks to Cindy Reece, P.E., for her contributions in revising this edition to reflect significant changes in the exam format.
SECTION 1
SPE Petroleum Engineering Certification Program Exam

The certification examination is given open-book style in two 3.5-hour sessions. You will be asked to work 70 multiple-choice problems—35 in the morning and 35 in the afternoon. Your score will be based on the number of problems you solve correctly.

Example Items To Take to the Examination*

1. Wristwatch.
2. Straight edge, 45° triangle, 30°/60° triangle, French curve.
3. Any battery-operated, charged, non-printing, non-communicating, silent calculator (one you are familiar with) and extra battery pack. Do not count on available electrical socket. Calculators may not be programmable.
4. Reference books, but not unbound material or handwritten notes.

Writing instruments are supplied onsite, so do not bring pens, pencils, or erasers.

Calculator Policy
You may not use a calculator that communicates with other devices or that may otherwise compromise the security of the examination. Of particular concern is the ability to type in text, store it in memory, and then communicate via wireless or cable connections to another calculator, personal computer, printer, or other electronic device. This policy is strictly enforced. A list of approved calculators is provided annually.

Along with cell phones and other electronic devices, any unapproved calculators will be confiscated by the proctor. If an unapproved calculator is found in your possession after the exam begins, you will be dismissed from the exam room and your exam will not be scored. Clearing the memories of prohibited calculators for use in examination room is not feasible due to exam sites with a large number of examinees. There are two issues here related to security that include calculators that can communicate with other units during the exam and calculators used to store text that is taken from the room. Clearing the memory satisfies only one of those issues.

Textbooks and Reference Materials

Following are specific textbooks and handbooks that you should find helpful. **Exam problems are written to reference the SPE Petroleum Engineering Handbook** (PEH). In October 2014, SPE will publish the **SPE Petroleum Engineering Certification and PE License Exam Reference Guide**. The Guide can be used in conjunction with the PEH during exam sessions. After 1 April 2015, the PEH and Guide are the only references allowed in the exam session room or computer center exam sessions. At a date to be announced, **SPE Petroleum Engineering Certification and PE License Exam Reference Guide** will be the only reference book allowed in the exam session, whether in a group exam or computer based testing.
SECTION 2
Test Specifications for SPE Petroleum Engineering Certification Program
Examination in the Discipline of Petroleum Engineering
(Effective January 2013)

Approximate Percentage of Examination

I. Common Knowledge
   A. Principles of mathematics and the physical sciences.
   B. Petroleum engineering terminology.
   C. Relevant industry and company design standards.
   D. Relevant industry regulatory/environmental law.
   E. Industry and/or company-provided technical software/informational databases.
   F. Project management techniques (costing, scheduling, contracting, logistics).
   G. Geoscience principles (pore pressure, fracture gradients, wellbore stability, etc.).
   H. Risk analysis/contingency planning.
   I. Surveillance/optimization techniques.
   J. Economic principles.
   K. Multidisciplinary team participation.
   L. Professionalism, including ethics and due diligence.

II. Drilling
   A. Tubulars.
   B. Cementing.
   C. Drilling fluids.
   D. Drillstring.
   E. Drilling mechanics.
   F. Hydraulics.
   G. Rig equipment capabilities.
   H. Directional/horizontal drilling.
   I. Wellheads.
   J. Well control/BOP.
   K. Solids control.
   L. Bits.

III. Completion, Production and Facilities
   A. Proper lift mechanism selection given a set of well conditions.
   B. Sucker rod pumping systems.
   C. Gas lift, including intermitters, plunger lift, or gas lift valves.
   D. Downhole pumps including ESPs, progressive cavity pumps, or jet pumps.
   E. Well and completion systems including nodal analysis.
   F. Inflow performance curve analysis.
   G. Production logging.
   H. 2D sand fracture treatments.
   I. Matrix acid treatments.
   J. Tubing and downhole equipment.
K. Plug and abandonment procedures.
L. Remedial/recompletion operations (squeezing cementing, sand control, perforating, etc.).
M. Selections of piping to accommodate flow rate, total pressure and pressure drop considerations.
N. Compressor application and sizing parameters.
O. On-site processing equipment including separators, heater treaters, or dehydrators.
P. On-site storage vessels including piping, valves and venting.
Q. Logging methods (wireline, MWD/LWD, open hole, cased hole).
R. Well testing (wireline, production test, DST, well test analysis).
S. Derivation of properties from formation evaluation data included lithology, mechanical rock properties, fluid properties and borehole dimension.
T. Mechanical rock properties.

IV. Reservoir

A. Reservoir geoscience.
B. Oil/gas reservoir performance.
C. Methods to determine net pay.
D. Phase behavior/reservoir fluids.
E. Single/multiphase flow in porous media.
F. Gravity/capillary and viscous forces.
G. Methods for estimating reserves and recovery.
H. Reservoir development techniques (patterns, rates, stimulation, etc.).
I. Water/gas injection.
J. Reservoir simulation techniques.
K. Physical measurements (e.g., acoustic, nuclear, electrical).
L. Lithology.
M. Fluid properties.
N. Coring (SWC, full hole core, petrophysical/lab analysis).

TOTAL 100%

Notes:
1. The knowledge areas specified as A, B, C, etc. are examples of kinds of knowledge, but they are not exclusive or exhaustive categories.
2. This examination contains 70 multiple-choice questions. Examinee works all questions.
3. The committee chose to fold the Common Knowledge section into the other content sections.
SECTION 3

Code for Professional Conduct

Preamble
SPE Professionals are to exhibit the highest standards of competency, honesty, integrity, and impartiality; and are fair and equitable; and accept a personal responsibility for adherence to applicable laws, the protection of the environment, and safeguarding the public welfare in their professional actions and behavior. These principles govern professional conduct in serving the interests of the public, clients, employers, colleagues, and the profession.

Code of Professional Conduct

SPE Professionals:

1. Offer services in the areas of their competence and experience affording full disclosure of their qualifications.

2. Consider the consequences of their work and societal issues pertinent to it and seek to extend public understanding of those relationships.

3. Are honest, truthful, ethical, and fair in presenting information and in making public statements reflecting on colleagues’ professional matters and their professional role, whether verbal or through printed or electronic media.

4. Engage in professional relationships without bias or prejudice based on race, religion, gender, age, ethnicity, national origin, sexual orientation, marital status, socioeconomic status, political affiliation, or disability.

5. Act in professional matters for each employer or client as faithful agents or trustees by not disclosing without consent, or taking improper advantage of, anything of a proprietary or confidential nature concerning the business affairs or technical processes of any present or former client or employer.

6. Disclose to affected parties known or potential conflicts of interest or other circumstances which might influence-or appear to influence-judgment or impair the fairness or quality of their performance.

7. Are responsible for enhancing their professional competence throughout their careers, for promoting others to advance their learning and competence, and not falsely obtaining competency credentials through misrepresentation of experience or misconduct.

8. Accept responsibility for their actions; seek and acknowledge criticism of their work; offer honest and constructive criticism of the work of others; properly credit the contributions of others; and do not accept credit for work that is not theirs own work.

9. When perceiving a consequence of their professional duties to adversely affect the present or future public health and safety shall formally advise their employers or clients, and subordinates and, if warranted, consider further disclosure to appropriate parties.

10. Seek to adopt technical and economic measures to render potentially adverse impacts to environment or the health, safety, and security of the public as low as reasonably practicable.

11. Act in accordance with all applicable laws and the canons of ethics as applicable to the practice of engineering as stated in the laws and regulations governing the practice of engineering in their country, territory, or state, and lend support to others who strive to do likewise.
12. Do not engage to offer or accept bribes or facilitate payments, either directly or indirectly, not only in compliance with anti-bribery laws but also in maintenance of high professional and ethical standards.

— Approved by the Board of Directors February 25, 1985
— Revised by the Board of Directors September 26, 2004
— Revised by the Board of Directors September 19, 2010
— Revised by the Board of Directors September 29, 2013
References

SECTION 4

Sample SPE Petroleum Engineering Certification Program Examination

The certification examination will be composed of 70 multiple-choice problems that cover the technical specialty areas described in Section 2.

The main purpose of this sample examination is to illustrate typical problem statements and correct answers for a portion of the topics that may be covered on the exam. Additional topics related to the listed technical specialty areas may also be included in the examination. This sample exam problems will not prepare you for the exam. It is intended only as a guide. It is recommended that you spend adequate time preparing for the examination.
Example Problems and Correct Answers for the Petroleum Engineering Certification Exam
1. Which of the following factors has the LEAST impact on casing seat selection?
   A. Rate of Penetration
   B. Pore pressure
   C. Kick tolerance
   D. Fracture gradient

2. When considering calculation methods for survey points, the LEAST precise method is:
   A. Circular arc
   B. Minimum curvature
   C. Radius of curvature
   D. Tangential

3. Which of the following is NOT a typical purpose for a BHA?
   A. Assure casing can be run into a hole
   B. Control direction and inclination in directional holes
   C. Increase severity of doglegs, keyseats and ledges
   D. Protect the drill pipe from excessive bending and torsional loads

4. Which of the following is a typical characteristic of plug flow cement placement?
   A. Reynolds number less than 100
   B. Large cement volumes
   C. High displacement rates
   D. Short cementation times

5. Which of the following is NOT a typical cause for a fishing job?
   A. Cementing error
   B. Differential sticking
   C. Swelling zone
   D. Use of oil-base mud

6. Which of the following is NOT a component of the hoisting equipment for a drilling rig?
   A. Crown block
   B. Drawworks
   C. Drilling line
   D. Rotary table
7. Which of the following is NOT a primary function of drilling fluids?
   A. Cuttings removal
   B. Frac proppant
   C. Lubrication and cooling
   D. Well control

8. Which of the following methods is MOST likely to hydrostatically balance a well kick with only one circulation?
   A. Concurrent
   B. Driller’s
   C. Toolpusher’s
   D. Wait and weight

9. Critical rotary speed longitudinally (rpm*) is calculated by \( \text{rpm}^* = \frac{258,000}{L} \), where \( L \) is the total length of the drill string (ft). Which of the following is a multiple of rpm* at which secondary and higher harmonic vibrations will occur?
   A. 2
   B. 8
   C. 16
   D. 32

10. Which of the following is NOT a colloidal polymer?
    A. Xantham gum
    B. Starch
    C. Sodium carboxy methyl cellulose
    D. Hydroxyethyl cellulose

11. Which of the following is a major consideration for cuttings transport in horizontal wells?
    A. Annulus size
    B. Drilling Rate
    C. Eccentricity
    D. Rotary speed

12. Which of the following is NOT a routine roller cone bearing package description?
    A. Friction-ball-friction
    B. Friction-ball-roller
    C. Roller-ball-friction
    D. Roller-ball-roller
13. In comparing the API specs for L-80 and N-80 tubulars, which of the following statements is TRUE?
   A. Minimum yield strength is different
   B. Maximum yield strength is the same
   C. Minimum tensile strength is different
   D. Minimum elongation is the same

14. Which of the following is NOT a typical separator type?
   A. Horizontal
   B. Slant
   C. Spherical
   D. Vertical

15. Which of the following is NOT a typical casing hanger type?
   A. Slip-weld
   B. Nominal flange
   C. Boll-weevil
   D. Automatic

16. The control pressure for a surface safety valve is most likely equal to:
   A. Valve body pressure divided by actuator ratio
   B. Actuator ratio divided by valve body pressure
   C. Two times valve body pressure divided by actuator ratio
   D. Valve body pressure multiplied by actuator ratio

17. The material for sealing element when approaching 450 degrees F (232 degrees C) and 15,000 psi (103,422 KPa) differential is MOST likely:
   A. Glass-filled Teflon
   B. Kalrez
   C. Nitrile
   D. Viton

18. Tubing elongation MOST likely occurs with:
   A. Ballooning
   B. Buckling
   C. Reverse Ballooning
   D. Temperature Reduction
19. Which of the following is NOT an API classification for oil well pumps?
   A. Tubing type with extension shoe and nipple
   B. Tubing type, traveling barrel with bottom hold-down
   C. Rod type, stationary barrel with top hold-down
   D. Rod type, traveling barrel

20. Which of the following has the LEAST volumetric efficiency for rod pumped wells?
   A. High fluid level with no gas interference
   B. Gaseous wells with fair downhole separation
   C. Foamy liquid or gaseous conditions
   D. Ample pump submergence with good separation

21. A caliper survey has been run on a producing gas well. It shows that the casing is partially collapsed 500 ft (152.4 m) above the perforations. The well is starting to load up with fluid, so a decision has been made to install a small diameter tubing string with a packer set just below the partially collapsed interval to protect the casing from pressure, temperature fluctuations and other forces that could result in further collapse.

   What type of packer should be used in this application?

   A. Weight-set packer
   B. Tension-set packer
   C. Rotation-set packer
   D. Hydraulic-set packer
22. A platform is producing surplus gas that must be sold into a nearby pipeline; flaring is not permitted. The gas has the following characteristics:
- gas gravity = 0.689 SG (Air = 1)
- ratio of specific heats = 1.206
- molecular weight = 20
- supercompressibility factor = 0.022
Wells on the platform produce a total of 18 mmcf/d (509,703 m³/d) dry gas (after separation and dehydration). Platform fuel use is 6 mmcf/d (169,900 m³/d). The gas is cooled after leaving the dehydrator to a temperature of 60°F (15.6°C). Pressure at the gas cooler outlet is 227 psig (1,565 KPa). Pipeline pressure is 1,050 psig (7239 KPa).

What minimum horsepower, hp, would be required to compress the surplus gas from this platform for sale into the pipeline?

A. 1,191
B. 1,238
C. 1,787
D. 2,649
23. What type problem does the below dynamometer card indicate that would cause an excessive number of rod parts in the lower portion of the rod string in this well?

A. Excessive friction  
B. Overtravel  
C. Plunger sticking  
D. Fluid pound
24. A well is to be fracture stimulated down the production casing with the following conditions:
Fracture propagation gradient: 0.95 psi/ft (2.19 SG)
Near well pressure losses: 1,000 psi (6,895 KPa)
Casing friction pressure losses: 1,600 psi (11,032 KPa)
Surface piping friction losses: 300 psi (2,068 KPa)
Stimulation rate: 65 bbl/minute (10.33 m³/min)
Perforations: 18,100 ft (5,517 m) MD/16,100 ft (4,907 m) TVD
Fluid Density: 8.5 lbm/gal (1.02 SG)
50% Standby Horsepower on location
Pump truck rated horsepower: 2,000/truck.
Assume 85% Pump Efficiency

How many pump trucks will be required?

A. 11
B. 14
C. 16
D. 17

25. A 10,000 HP compressor bank is going to be added to a large pipeline compressor station. An inlet meter station is located 1,200 ft (366 m) away from the new compressor site. Pressure at the meter run is 60 psig (414 KPa). Gas from the meter station will be used for fuel. The gas pressure at the fuel line header inside the new compressor site is specified at 26 psig (179 KPa). The gas will be at 60°F (15.6°C). Assume fuel usage will be 240 scfd (6.8 m³/d) per HP for the new compressors.

What minimum diameter, in/(mm) fuel line should be installed to provide fuel gas to the new compressor site from the meter run?

A. 1.5 (38)
B. 3.5 (89)
C. 5 (127)
D. 6 (152)
26.
The following readings were made by a field gas technician at a dry gas sales meter.

Static pressure: 800 psig (5,516 KPa)
Differential: 15-in. (381 mm) H₂O
Temperature: 130°F (54.4°C)
Gas Specific Gravity: 0.62 (Air=1)
Meter run: 4.026-in. (102.3 mm) ID
Orifice plate: 1.5-in. (38.1 mm)

Neglect viscosity, super-compressibility and compression factors (assume each of these equals 1.0). The only impurities are 13 vol-% CO₂ and 0.8 vol-% N₂.

Using standard meter tables
\[ F_b = 460.8 \]
\[ F_g = 1.27 \]
\[ F_{pb} = 1.0000 \]

What is the daily natural gas flowrate, mcfpd (m³/d), most likely to be on the gas purchasers’ statement using a 14.73 psi (101.5 KPa) pressure base and 60°F (15.6°C) temperature base?

A. 1,152 (32,621)
B. 1,328 (37,605)
C. 1,341 (37,973)
D. 1,458 (41,286)
27. A gas well with 40 ppm H₂S and 14 mole-% CO₂ is planned to be produced up a string of tubing cemented in the well as a “tubingless completion” (i.e., the tubing is actually small-diameter production casing).

Initial shut in pressure will be 12,000 psi (82.737 MPa). Initial flowing pressure will be 8,000 psi (55.158 MPa). Flowing pressure will decline to 2,000 psi (13.79 MPa) in less than six months. Surface temperature is 75°F (23.9°C). Static bottomhole temperature is 330°F (165.6°C) at 15,200 ft (4,633 m) TVD. Flowing surface temperature is 120°F (48.9°C). Both T95 and P110 tubing (casing) strings are available and will meet all required stress considerations. Your field foreman would prefer to run just one grade of pipe to avoid confusion on the rig.

Of the possible recommendations below, what would you recommend to management with your concern being sulphide stress cracking (SSC) of the tubing (casing) string in this well?

A. The partial pressure of sour gas is not great enough to need T95 grade pipe
B. Run all P110 grade pipe. Fast pressure decline mitigates problem with SSC
C. Recommend running T95 to at least 4,348 ft (1,325 m) from the surface
D. Recommend running T95 to at least 6,250 ft (1,905 m) from the surface

28. A plug has been set in a profile nipple below a packer in a well. To confirm that the plug will hold, it has been decided to pressure up on the tubing to 9,000 psi (62.1 MPa).

The well is standing full of fresh water. The packer is set at 6,000 ft (1,829 m) and has a 3.5-in. (89 mm) bore. The pipe string is all 2 7/8-in. (73 mm) OD, 6.5 lbm/ft (9.67 kg/m) L-80, EUE, 8-round thread tubing equipped with a seal assembly that allows free travel inside the packer bore. A pressure of 1,000 psi (6.9 MPa) will be applied to the tubing x casing annulus.

Ignoring temperature and ballooning effects, how far up the packer bore will the seal assembly travel, inches (centimeters), when the pump reaches maximum pressure?

A. 54.7 (138.9)
B. 33.1 (84.1)
C. 28.4 (72.1)
D. 4.6 (11.7)
29.  
A tank is filled with produced water with a density of 8.6 lbm/gal (1.03 SG). A decision has been made to use the fluid for a workover, but the density is too low. Brine with a density of 10.0 lbm/gal (1.20 SG) is to be mixed with fluid in the tank until the contents have the proper density for the job. The brine is to be pumped through a nozzle on the end of a pipe to agitate the tank and ensure the fluid is constantly, thoroughly mixed. The nozzle has a diameter of 1/2-in. (12.7 mm) and a pump rate of 200 gal/min (0.757 m³/min) has been selected.

What pressure drop, psi (KPa) can be anticipated across the nozzle under these conditions? Assume a nozzle coefficient of 0.95.

A. 147 (1,014)  
B. 188 (1,294)  
C. 597 (4,116)  
D. 956 (6,588)

30.  
A pressure relief valve is needed to protect a petroleum storage tank from over-pressure. The relief valve will discharge into a low-pressure vent system with a constant pressure of 0.5 psig (3.4 KPa). The scrubber on this low pressure vent system cannot handle peak flowrates in excess of 6.0 scfm (10.2 m³/hr).

The relief valve is to be set to allow a 5 psig (34.5 KPa) buildup in the tank with a 1.6 psig (11.0 KPa) setpoint pressure before the relief valve opens. Gas in the tank has a specific gravity of 0.68 (Air = 1.0). The ratio of specific heats of the gas, \( k = C_p/C_v = 1.10 \). Assume the relief valve has a coefficient, \( K \), of 5.212 x 10⁻⁴.

What diameter relief valve orifice, inches (cm), should be specified for this application?

A. 6.4 (16.3)  
B. 6.0 (15.2)  
C. 5.8 (14.7)  
D. 5.5 (14.0)

31.  
You are calculating the original gas in place using the volumetric method.

Which of the following has the LEAST influence on the final result?

A. Connate water saturation  
B. Initial reservoir pressure  
C. Permeability  
D. Porosity
32. Which of the following is the LEAST likely source for water which encroaches into a reservoir as pressure declines?

A. Artesian flow
B. Compressibility of the rock in the aquifer
C. Expansion of the water in the aquifer
D. Water coming out of solution from the oil as the pressure drops

33. Important characteristics of the production history of many coal-bed methane wells include:

A. Initial large and declining water cuts and low and improving gas production rates
B. Initial large but declining gas/liquid ratios and low but increasing water production rates
C. Stabilized gas/liquid ratios and decreasing gas rates
D. Stabilized gas/liquid ratios and increasing gas and water production rates

34. There are known effects of gas on logging tool responses.

Which of the following statements is correct?

A. Density log porosities are not affected by gas
B. Neutron log porosities are increased by gas
C. NMR log porosities are reduced by gas
D. Sonic log porosities are reduced by gas

35. For decline-curve analysis to be accurate, several conditions must be satisfied.

Which of the following conditions is not appropriate?

A. Drainage area of the well remains constant with time.
B. Skin factor of well is not changing with time.
C. Well is in transient flow regime.
D. Well produces at constant BHP.
36. A pressure buildup test is run on a well producing dry gas. Current average reservoir pressure is about 3,012 psia (20.77 $\times$ $10^3$ KPa) and the flowing bottomhole pressure at the time of shut-in was 1,126 psia (7.76 $\times$ $10^3$ KPa).

Which of the following statements about analyzing the test data using a semi-log method is most accurate?

A. A Horner plot of $p_{ws}$ vs. Horner time ratio will be required.
B. A Horner plot of $p_{ws}^2$ vs. Horner time ratio will be required.
C. Bottomhole pressure must be converted to pseudopressure and then a Horner plot of pseudopressure vs. Horner time ratio will be required.
D. Semi-log analysis cannot succeed for analysis of a gas-well pressure buildup test.

37. Volumetric estimate of original gas in place for gas reservoir A was 100 Bscf (2.831 $\times$ $10^9$ std m$^3$). A material-balance estimate, using a $p/z$ plot, was 50 Bscf (1.416 $\times$ $10^9$ std m$^3$).

Which of the following statements is most likely true?

A. One or more producing wells intended to produce from Reservoir A is probably completed by mistake in another non-communicating reservoir.
B. Some of the mapped gas may not be in pressure communication with the producing wells.
C. The estimate based on the $p/z$ plot cannot possibly be correct.
D. The reservoir almost certainly has water influx.

38. In a low-permeability gas formation, the deliverability curve determined from a plot of $\Delta p^2$ vs. $q$, using available test data from a four-point backpressure test with equal-length flow periods, will usually not be “stabilized.”

Therefore, the ability of the gas well to deliver gas at a given backpressure will be:

A. About the same as predicted from the deliverability curve plotted using available test data.
B. Greater than predicted from the deliverability curve plotted using available test data.
C. Less than predicted from the deliverability curve plotted using available test data.
D. Uncorrelated to the value predicted from the deliverability plotted using available test data.
39. The forecasted production between the current time and the estimated economic limit of a well using a well-defined decline curve is best regarded as

   A. Proved developed reserve
   B. Proved plus probable reserve
   C. Proved plus probable plus possible reserve
   D. Total resource

40. Thermal oil recovery processes increase recovery largely because they:

   A. improve vertical sweep efficiency to virtually 100% in most cases
   B. increase formation water mobility because of increased formation temperature
   C. reduce oil viscosity
   D. reduce residual oil saturation to near zero in swept areas
An oil reservoir was originally undersaturated and was known to have no water influx. The PVT properties as determined from a recombined fluid sample are shown on the attached curve. The field is to be waterflooded and part of the pre-flood strategy is to determine the new bubble point for this state of depletion. The initial reservoir pressure is 3,000 psia (20,684 KPa) with an initial oil saturation, \( S_{oi} = 0.90 \). The abandonment pressure is 1,200 psia (8,274 KPa). Cumulative oil production to the bubble point is 250,000 stb (1,261 m\(^3\)).

The reservoir oil formation volume factor follows the \( Bo \) plot below:

If the current reservoir pressure is 2,500 psia (17,237 KPa), what is the current oil formation volume factor, rb/stb, (res m\(^3\)/m\(^3\)) nearest?

A. 1.460
B. 1.450
C. 1.440
D. 1.240
A reservoir oil solution gas-oil ratio follows the $R_s$ plot below:

The initial reservoir pressure was 3,000 psia (20,684 KPa). What is the bubble point pressure, psia (KPa) of the oil nearest?

A. 3,000 (20,684)
B. 2,160 (14,893)
C. 1,000 (6,895)
D. Not enough information
An oil reservoir was originally undersaturated and was known to have no water influx. The field is to be waterflooded and part of the preflood strategy is to determine the new bubble point for this state of depletion. The initial reservoir pressure is 3,000 psia (20,684 KPa) with an initial oil saturation; $S_{oi} = 0.90$. The abandonment pressure is 1,200 psia (8,274 KPa). At the abandonment pressure the oil formation volume factor is 1.20. Cumulative oil production to the bubble point is 250,000 stb (39,750 m$^3$).

Using the above production information and saturations, assume $B_{ob} = 1.460$ rb/stb (res $m^3/m^3$) and the $B_{oi} = 1.441$ rb/stb (res $m^3/m^3$) and that rock and water expansion are negligible.

What is the new bubble point solution gas oil ratio, scf/stb (res $m^3/m^3$), that would be indicated by increasing the reservoir pressure with water injection such that all the free gas was driven back into the solution.

A. 465 (83)
B. 512 (91)
C. 816 (145)
D. 935 (166)
You have the following information on a reservoir:

<table>
<thead>
<tr>
<th>Pressure psia (KPa)</th>
<th>( B_0 ) Rb/stb (res m(^3)/m(^3))</th>
<th>( B_g ) Rb/scf (res m(^3)/m(^3))</th>
<th>( B_t ) Rb/stb (res m(^3)/m(^3))</th>
<th>( R_s ) Scf/stb (res m(^3)/m(^3))</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,500 (17,237)</td>
<td>1.498</td>
<td>0.001048 (0.00588)</td>
<td>1.498</td>
<td>721 (128)</td>
</tr>
<tr>
<td>2,100 (14,479)</td>
<td>1.429</td>
<td>0.001280 (0.00719)</td>
<td>1.562</td>
<td>617 (110)</td>
</tr>
<tr>
<td>1,300 (8,963)</td>
<td>1.292</td>
<td>0.002206 (0.0124)</td>
<td>1.980</td>
<td>409 (73)</td>
</tr>
</tbody>
</table>

Original reservoir pressure was 2,500 psia (17,237 KPa). Well test information and log analysis indicate the presence of a gas cap however, the size of the gas cap is unknown. The reservoir has exhibited the following production performance during depletion:

<table>
<thead>
<tr>
<th>Pressure psia (KPa)</th>
<th>( N_p ) Mstb (mm(^3))</th>
<th>( G_p ) mmmscf (mmm(^3))</th>
<th>( W_p ) Mstb (Mm(^3))</th>
<th>( R_p ) Scf/stb (m(^3)/m(^3))</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,500 (17,237)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2,100 (14,479)</td>
<td>3,375 (537)</td>
<td>2,997 (85)</td>
<td>0</td>
<td>888 (141)</td>
</tr>
<tr>
<td>1,300 (8,963)</td>
<td>7,964 (1266)</td>
<td>13,941 (395)</td>
<td>0</td>
<td>1,750 (278)</td>
</tr>
</tbody>
</table>

The rock and water compressibilities can be assumed to be negligible. There is no water influx.

What is the depletion drive index (dimensionless)?

A. 0.9995  
B. 0.2255  
C. 0.2342  
D. 0.3454
Using the above fractional flow curve, what is the average water saturation behind the flood front at water breakthrough?

A. 0.05
B. 0.72
C. 0.64
D. 0.68

46. What is the original oil in place in stb (m$^3$) of a reservoir with the following parameters?

Area = 80 acres, (323,749)
net pay thickness = 50 ft, (15.2 m)
average porosity = 20%,
initial water saturation, $S_{wc}$ = 10%,
initial gas saturation, $S_g$ = 10%,
Initial Oil Formation Volume Factor, $B_{oi}$ = 1.42 rb/stb, (m$^3$/m$^3$)
Initial Gas Formation Volume Factor, $B_{gi}$ = 0.8 rb/mscf. (0.00449 m$^3$/m$^3$)

A. 3,496,563 (555,954)
B. 3,933,633 (625,448)
C. 6,206,400 (986,818)
D. 300,000,000 (47,700,000)
47. Using the following parameters, what is the ratio of the gas cap to the oil rim, m?

Area = 80 acres, (323,749 m²)
net pay thickness = 50 ft, (15.2 m)
average porosity = 20%,
initial water saturation, \( S_{wc} \) = 10%,
initial gas saturation, \( S_g \) = 10%,
Initial Oil Formation Volume Factor, \( B_{oi} \) = 1.42 rb/stb, (m³/m³)
Initial Gas Formation Volume Factor, \( B_{gi} \) = 0.8 rb/mscf. (0.00449 m³/m³)

A. 0.125
B. 0.22
C. 0.5
D. not enough information

48. A density log in a shaly sand records a formation bulk density, \( \rho_b = 2.20 \text{ g/cm}^3 \). The correction factor for mudcake and hole rugosity is \( \Delta \rho = 0.05 \text{ g/cm}^3 \). From measurements on cores and produced fluids it is known that the matrix and fluid densities are, \( \rho_{ma} = 2.68 \text{ g/cm}^3 \) and \( \rho_f = 1.2 \text{ g/cm}^3 \).

What is the density log porosity, %?

A. 27
B. 29
C. 32
D. 36
49.
A producer-injector pair of wells in an infinite-acting reservoir has been producing two weeks. The distance between the wells is 500 feet (91.44 m). Assume that the injection and production rates are equal at 1,500 bpd (238.48 m$^3$/d) and that the rock and fluid properties are the same for both injector and producer.

Reservoir Properties for this formation are:
- Permeability = 250 md
- Porosity = .22
- Net thickness = 30 ft (9.14 m)
- Oil viscosity = .5 cp
- Water viscosity = .5 cp
- Total compressibility = 4E-5 psi (2.76E-4 KPa)
- Injector Skin = 10
- Producer Skin = 0
- Wellbore radius of both well is 5.5 inches (139.7 mm)
- Bo = Bw = 1.0 rb/stb

Calculate the expected pressure drop, psi (KPa), in the production well.

A. 26.91 (185.54)
B. 98.78 (681.06)
C. 239.98 (1654.60)
D. 656.42 (4525.86)

50.
A gas well has been found to be declining exponentially. The observed production rate on 1 January 2004 was 0.6 Bscf/month ($1.7 \times 10^7$ std m$^3$/month), and on 1 January 2005, it was 0.4 Bscf/month ($1.133 \times 10^7$ std m$^3$/month). The economic limit for the well is estimated to be 0.003 Bscf/month ($8.495 \times 10^5$ std m$^3$/month).

Estimate the remaining reserves, Bscf (std m$^3$), for the well as of 1 January 2005.

A. 21.5 ($6.09 \times 10^8$)
B. 17.69 ($5.01 \times 10^8$)
C. 1.791 ($5.07 \times 10^7$)
D. 1.474 ($4.17 \times 10^7$)
51. Which of the following has the LEAST influence on drill pipe stretch?
   A. BHA weight  
   B. Drill pipe weight  
   C. Mud density  
   D. Traveling block weight

52. Which of the following is MOST LIKELY a descriptor for a diamond bit?
   A. Crown  
   B. Journal  
   C. O-ring Seal  
   D. Shirrtail

53. Which of the following is NOT a description of fluid flow?
   A. Laminar  
   B. Plastic  
   C. Plug  
   D. Turbulent

54. Which of the following is NOT a key rheological property of drilling fluids?
   A. Yield point  
   B. Plastic viscosity  
   C. Gel Strength  
   D. Funnel viscosity

55. Which of the following has the LEAST influence on bit nozzle pressure drop?
   A. Bit diameter  
   B. Flow rate  
   C. Mud density  
   D. Nozzle area

56. Which of the following is NOT a typical section view for directional wells?
   A. Double build  
   B. Double twist  
   C. S type  
   D. Slant type
57. Which of the following is a conventional rotary shouldered connection size?
   A. 4-1/2” REG
   B. 5-5/8” REG
   C. 6-1/2” REG
   D. 7-1/2” REG

58. Which of the following is a DISADVANTAGE of air drilling?
   A. Differential pipe sticking is eliminated
   B. Downhole explosions or fire may occur
   C. Lost circulation may be reduced
   D. Reduced thawing of frozen zones

59. Which of the following is FALSE regarding leak-off tests?
   A. Unpurged air can affect the shape of the leak-off test curve
   B. There are two phases of fracturing a formation, initiation and extension
   C. The pressure to initiate is usually less than the pressure to extend
   D. The initial pressure increase vs. volume pumped reflects elastic rock deformation

60. Which of the following is MOST LIKELY regarding cement flow regimes?
   A. Laminar flow has the smallest displacement efficiency
   B. Plug flow is very inefficient w/small volumes displacing low density mud
   C. Turbulent flow gives low displacement efficiency
   D. Turbulent flow requires the longest pumping times

61. When backing-off a stuck drill string, which of the following would NOT be a typical step?
   A. Twist the string one counter-clockwise turn per 1,000 feet of free string
   B. Pull the buoyed weight of the string above the stuck point
   C. Fire the shot after working the torque down to the tool joint to be backed off
   D. Twist the string one clockwise turn per 1,000’ of free string

62. Which of the following is NOT a typical contributing factor in axial friction forces?
   A. Bending of the drill string in a dog leg
   B. Buoyed weight of the drill string lying on the low side
   C. Hanging up of drill string component on a ledge
   D. Packing of the drill string in a cuttings bed
63. Which of the following does NOT result in collapse of the tube?  
   A. Elastic Collapse Pressure  
   B. Plastic Collapse Pressure  
   C. Transition Collapse Pressure  
   D. Yield-Strength Collapse Pressure

64. The primary function of the counter-balance system in rod pumped wells is:  
   A. Speed reduction of the prime mover to suitable pumping speeds  
   B. Store energy on the downstroke and release energy on the upstroke  
   C. Store energy on the upstroke and release energy on the downstroke  
   D. Supply the mechanical energy to transmit to the pump and lift fluids

65. For bellows-type gas-lift valves, valve spread is:  
   A. The difference between opening and closing pressures  
   B. The difference between annular and bellow pressures  
   C. The depth difference between the top and bottom valves  
   D. The depth difference between adjacent valves

66. Which of the following would be a typical path for gas through a separator?  
   A. Primary separation, liquid accumulation, secondary separation, gas outlet  
   B. Primary separation, mist extractor, liquid accumulation, gas outlet  
   C. Primary separation, secondary separation, liquid accumulation, gas outlet  
   D. Primary separation, secondary separation, mist extractor, gas outlet

67. Which of the following is NOT a primary mechanism in separation devices?  
   A. Centrifugal  
   B. Gravity  
   C. Impingement  
   D. Radioactivity

68. Which of the following is NOT a key assumption for matrix acidizing?  
   A. Acid penetrates uniformly and radially  
   B. Formation is homogeneous  
   C. Pore size varies widely  
   D. Reaction rate declines uniformly with decreasing acid concentration
69.
The fracturing fluid coefficient is a key factor in modeling an induced fracture. Which of the following is NOT a category for fracture fluids?
   A. Conductivity-controlled fluids
   B. Reservoir-controlled fluids
   C. Viscosity-controlled fluids
   D. Wall-building fluids

70.
Which of the following is NOT a typical class of pipe cutters?
   A. Acid
   B. Jet-shaped charge
   C. Outside cutter
   D. Tubing punch

71.
A pump is needed to move a high viscosity, heavy (high specific gravity) crude oil from a storage tank to a treating facility for processing. The tank is not insulated and it is located in a cold-weather environment. The field from which this oil is produced has a low reservoir pressure, and the oil is produced in slugs that re-fill the tank sporadically. The oil must be moved at a closely controlled rate to the treating facility to avoid overloading it.

What type pump, based on service capabilities and cost, should be recommended for this service?
   A. Centrifugal pump
   B. Gear pump
   C. Reciprocating (plunger) pump
   D. Turbine pump

72.
A caliper survey has determined that there has been a uniform 65% wall loss in a 5-in. (127 mm) 23.2 lbm/ft (34.5 kg/m) T95 casing string. Neglecting axial/hoop stresses.

What is the new burst pressure rating of this casing string in psi/(Mpa)?
   A. 5,550 (38.3)
   B. 6,350 (43.78)
   C. 10,340 (71.29)
   D. 14,300 (98.6)
73. An electric motor is needed for a hoist. The motor is expected to provide a force of 744 lb \( (337.5 \text{ kg}) \) at the edge of a 24-in. \( (61 \text{ cm}) \) diameter pulley. The motor will run at 1200 RPM and the pulley will be attached to a gearbox to provide the correct line speed for the hoist. Assume the motor operates at 85% efficiency.

What size, hp (KW), motor should be specified for this application?

A. 170 HP (126.8)  
B. 200 HP (149.1)  
C. 340 HP (253.5)  
D. 400 HP (298.3)

74. A recently drilled well is being completed. The well was drilled with 14 lbm/gal \( (1.68 \text{ SG}) \) mud with no mud losses experienced while drilling the well. The 5 ½-in. \( (140 \text{ mm}) \), 15.50 pound/ft \( (23.06 \text{ kg/m}) \) casing has been perforated from 10,129 ft \( (3,087.3 \text{ m}) \) to 10,141 ft \( (3,091.0 \text{ m}) \). A full string of 2 3/8-in. \( (60 \text{ mm}) \) tubing has been run in the well to the top perforation.

The well was being circulated on its third bottoms-up with 8.7 lbm/gal \( (1.04 \text{ SG}) \) filtered water when the pump failed. The crew closed the blowout preventer and installed a closed valve in the top of the tubing string. Unfortunately, they left the valve on the annulus flowline to the pit open while the pump was repaired. Someone noticed that the well was flowing, and the crew closed the annulus valve. The pit had gained 10 bbl \( (1.6 \text{ m}^3) \) of fluid. Stabilized pressures after 30 minutes are:
- Shut-in tubing pressure, 495 psi \( (3,413 \text{ KPa}) \);  
- Shut-in annulus pressure, 225 psi \( (1,551 \text{ KPa}) \).

The type of fluid most likely composing the kick is:

A. Natural gas  
B. Oil  
C. Saltwater  
D. Drilling mud
75.
A well has ceased flowing due to a buildup of saltwater in the tubing. The well is standing full of produced fluid with a density of 8.9 lbm/gal (1.067 SG). A pumping unit is to be installed to lift the fluid from a depth of 10,000 ft (3,048 m). Expected produced water rate is 220 bbl/D (35 m³/day). The pumping unit will be counterbalanced such that essentially all the sucker rod and fluid load will be offset by the counterweights. The pumping unit manufacturer requires a prime mover having 125% excess power to run the unit.

What is the rated horsepower, hp (KW), of the prime mover needed to run the pumping unit?

A. 15 (11)  
B. 20 (15)  
C. 35 (26)  
D. 40 (30)

76.
A recently-drilled gas well has been completed, but initial flowrates from the well are disappointing. The well has the following characteristics:

The pay zone perforations are centered at 15,800 ft (4,816 m).
The static reservoir pressure is 0.63 psi/ft (1.45 SG).
The fracture gradient at the perforations is 0.95 psi/ft (2.19 SG).  
Skin = -20 psi (-138 KPa).
The pay zone is a tight, highly-consolidated clean sandstone. Permeability is estimated to be 0.05 mD.

What treatment technique would you recommend to stimulate this well?

A. High rate, high volume fracture stimulation  
B. Low rate “matrix” hydrochloric acid stimulation  
C. Sand control treatment to reduce sand collection in the wellbore  
D. Scale removal workover
77.
A pumping unit is to be installed on a 5,000 ft (1,524 m) well. The foreman wishes to use 1-in (25.4 mm), \( \frac{7}{8} \) -in. (22.2 mm) and \( \frac{3}{4} \) -in. (19.1 mm) sucker rods to make up the string so he can use his existing inventory and minimize the purchase of new rods. Unfortunately, he only has a limited number of 1-in. (25.4 mm) sucker rods and he will have to buy some of these.

What total length, feet (meters), of 1-in. (25.4 mm) sucker rods must be installed in this well if a 2-in. (50.8 mm) pump plunger is needed to achieve the production rate required on this well?

A. 1,435 (437.4)  
B. 1,635 (498.3)  
C. 1,930 (588.3)  
D. 2,260 (688.8)

78.
Three storage tanks are delivered to the site of a new producing well. The tanks appear to be unusual in size. No tank table was delivered with the tanks. The well is to be placed on production as soon as the tanks are set. The basic dimensions of the tanks are:

- Tank outside diameter: 15.0 ft (4.57 m)  
- Shell thickness: 0.35-in. (8.9 mm)  
- Tank shell height: 17 ft (5.18 m)  
- Overflow line outlet: base, 8-in. from top of tank (203.2 mm)

What is the usable storage capacity of the tank battery to the nearest barrel (cubic meter)?

A. 509 (80.9)  
B. 1,527 (242.8)  
C. 1,539 (244.7)  
D. 1,593 (253.3)
79.
A producing gas well is to be treated with a scale removal chemical at a low pump rate. The well is equipped with a polished-bore receptacle above the production packer with a 20-ft (6.1 m) seal assembly that travels freely. Bottomhole temperature is 300°F (149 °C). Gas temperature at the surface is 120°F (49 °C). Once the well is at thermal equilibrium during the pumping job, the average temperature of the tubing string will be reduced by 25°F (-4 °C) over its length. The tubing is tapered with 2,560 ft (780 m) of 3 ½-in (89 mm) tubing at the surface with 5,440 ft (1,658 m) of 2 7/8-in. (73 mm) tubing above the seal assembly. The tubing is all N-80 grade material.

How far, inches (centimeters), up the PBR will the tubing travel due to thermal contraction during this pumping job, ignoring pressure effects.

A. 1.4 (3.6)
B. 5.3 (13.5)
C. 16.6 (42.2)
D. 18.6 (47.2)

80.
A double-acting duplex pump is going to be used to fill a tank from a water pit. The foreman does not know the pump output, but he wants an estimate of the time required to fill the 500 bbl (79.5 m³) tank with water.

Each liner has an internal diameter of 5 ½-in. (14 cm) and an overall stroke length of 14-in. (35.6 cm). The rod diameter for each plunger is 2-in. (5.1 cm). The pump is running at a speed of 65 strokes per minute.

Assuming a pump efficiency of 80%, how long will it take for the pump to fill the 500-bbl (79.5 m³) tank?

A. 1.00 hours
B. 1.17 hours
C. 1.25 hours
D. 2.50 hours

81.
Which of the following statements is TRUE regarding undersaturated oil reservoirs?

A. The two phase and single phase factors are equal above the bubble point
B. The initial solution gas-oil ratio does not equal the solution gas-oil ratio at a specified pressure above the bubble point
C. Below the bubble point, the two-phase factor decreases while pressure decreases
D. Below the bubble point, the single phase factor increases while pressure decreases
82. Which of the following is the LEAST likely characteristic of a reservoir fluid?
   A. Compressible liquid
   B. Gas
   C. Incompressible liquid
   D. Superfluid

83. Reservoir simulators are well-suited to help us determine
   A. Aquifer size and strength, remaining reserves, corporate overhead
   B. Future water production, optimal infill well location, results of fracture stimulation treatments
   C. Optimal well spacing in reservoirs, coning characteristics of wells, and optimal flood patterns in improved recovery projects
   D. Unique reservoir description, optimal enhanced recovery method, good matches of reservoir history

84. The factors that cause recovery factors to vary in uncertain ways in oil reservoirs do not include
   A. distribution of permeabilities vertically and horizontally
   B. presence and location of reservoir boundaries
   C. presence and location of reservoir heterogeneities
   D. unexpected variations in oil prices

85. Each type of logging tool has special formation evaluation applications.

Which of the following statements is FALSE?

   A. Pressure versus depth measurements can be used to identify reservoir fluids and fluid contacts
   B. NMR and density logs can be combined to predict gas-corrected formation porosity in gas-bearing zones
   C. Resistivity measurements alone can be used to differentiate oil zones from gas zones
   D. NMR fluid characterization logs can be used to identify low-resistivity pay zones.
86. Given accurate test data, the exponent, $n$, in the Rawlins-Schellhardt gas-well deliverability equation should be

$$q = C \left( \frac{p}{P_{wf}} \right)^n$$

A. less than 0.5.
B. between 0.5 and 1.0.
C. greater than 1.0.
D. between 1.0 and 2.0.

87. A reservoir produces gas at an initial gas/liquid ratio (GLR) of 20,000 scf/STB (3,561 std m$^3$/std m$^3$). After some period of production at constant GLR, the producing GLR begins to increase with time. Essentially all the produced liquids are gas condensate.

The reservoir fluid is most likely which one of the following types?

A. Black oil
B. Dry gas
C. Gas condensate (retrograde gas)
D. Wet gas

88. The proper ranking of average (typical, not exceptional) oil reservoir recovery efficiency (from lowest to highest) by drive mechanism is

A. solution-gas drive; rock-and-fluid expansion drive; water drive; expanding gas-cap drive
B. solution-gas drive; expanding gas-cap drive; water drive; gravity drainage drive
C. rock-and-fluid expansion drive; solution-gas drive; water drive; expanding gas-cap drive
D. rock-and-fluid expansion drive; expanding gas-cap drive; gravity-drainage drive; water drive
89. Low-permeability or tight gas reservoirs ordinarily produce at economic rates because they are

A. Stimulated with long, highly conductive hydraulic fractures
B. Provided substantial tax and other economic incentives by governmental authorities
C. Drilled with very wide well spacing, often 640 acres \((2.59 \times 10^6 \text{ m}^2)\), and drain large areas efficiently with limited numbers of vertical wells
D. Completed in formations of massive thickness.

90. You are designing a waterflood for a reservoir that is currently below bubblepoint pressure and shut-in. The initial reservoir pressure was at the bubble point with no gas cap.

The oil reservoir has the following information:

- Flood Pattern: 5-spot
- Pattern Area: 80 acres \((323,749 \text{ m}^2)\)
- Formation Thickness: 59 feet \((18 \text{ m})\)
- Porosity: 16.0%
- Initial Water Saturation: 42.0%
- Oil formation volume factor at Original Pressure: 1.337 rb/stb \(\text{(m}^3/\text{m}^3)\)
- Primary Oil Produced: 450 mstb \((71,542 \text{ m}^3)\)
- Oil Formation Volume Factor at Current pressure: 1.165 rb/stb \(\text{(m}^3/\text{m}^3)\)
- Oil Viscosity at Current Pressure: 1.02 cp
- Water Viscosity at Current Pressure: 0.60 cp
- Oil saturation at Current pressure: 41.6%
- Average Water Saturation in Swept Zone at Breakthrough: 66.0%
- Water formation volume factor: 1.000 rb/stb \(\text{(m}^3/\text{m}^3)\)

The fillup volume in thousands of bbls (mstb) \(\text{(m}^3)\) is most nearly:

A. 0 (0)
B. 960 (152,640)
C. 2,092 (332,628)
D. 2,542 (404,178)
A reservoir oil solution gas-oil ratio follows the $R_s$ plot below:

![Graph showing $R_s$ vs. Pressure, psia]

The initial reservoir pressure was 3,000 psia (20,684 KPa). If the current reservoir pressure is 2,500 psia (17,237 KPa), what is the oil solution gas-oil ratio (scf/stb) ($\text{m}^3/\text{m}^3$) nearest?

A. 375 (67)  
B. 779 (139)  
C. 935 (166)  
D. Not enough information
An oil reservoir was originally undersaturated and was known to have no water influx. The field is to be waterflooded and part of the preflood strategy is to determine the new bubble point for this state of depletion. The initial reservoir pressure is 3,000 psia (20,684 KPa) with an initial oil saturation; \( S_{oi} = 0.90 \). The abandonment pressure is 1,200 psia (8,274 KPa). At the abandonment pressure the oil formation volume factor is 1.20. Cumulative oil production to the bubble point is 250,000 stb (39,750 m\(^3\)).

Using the above production information and saturations, assume \( B_{ob} = 1.460 \text{ rb/stb} \) and \( B_{oi} = 1.441 \text{ rb/stb} \) and that rock and water expansion are negligible.

If the new solution gas oil ratio is 750 scf/stb, (134 m\(^3\)/m\(^3\)) what is the new bubble point pressure, psia (KPa), nearest?

- A. 3,000 (20,684)
- B. 2,160 (14,893)
- C. 1,800 (12,411)
- D. 1,200 (8,274)
You have a PVT analysis for a volumetric reservoir which was undersaturated at the original reservoir conditions of 6,258 psia (36,890 KPa) and 205º F (96 ºC). The reservoir has produced at a constant producing GOR until a marked decrease in the producing GOR was noted. At this point, the cumulative production form the reservoir was 231 mstb (36,729 m³) of oil. The average oil saturation initially in the reservoir was determined from logs to be 80%.

### Differential Liberation:

<table>
<thead>
<tr>
<th>Pressure Psia (KPa)</th>
<th>Formation Volume Factor (rb/bbl resid oil at 60º F)</th>
<th>Solution GOR (scf/stb) (m³/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6,258 (43,149)</td>
<td>1.343</td>
<td>733 (130)</td>
</tr>
<tr>
<td>5,000 (34,475)</td>
<td>1.355</td>
<td>733 (130)</td>
</tr>
<tr>
<td>4,235 (29,200)</td>
<td>1.366</td>
<td>733 (130)</td>
</tr>
<tr>
<td>3,500 (24,133)</td>
<td>1.315</td>
<td>595 (106)</td>
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<tr>
<td>2,780 (19,168)</td>
<td>1.281</td>
<td>503 (90)</td>
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<td>2,400 (16,548)</td>
<td>1.241</td>
<td>394 (70)</td>
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<td>1,900 (13,101)</td>
<td>1.208</td>
<td>305 (54)</td>
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<td>1,400 (9,653)</td>
<td>1.177</td>
<td>218 (39)</td>
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<td>900 (6,206)</td>
<td>1.146</td>
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<td>400 (2,758)</td>
<td>1.117</td>
<td>55 (9.8)</td>
</tr>
<tr>
<td>100 (689)</td>
<td>1.101</td>
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<td>15 (103)</td>
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</table>

### Separator Flash Liberation:

<table>
<thead>
<tr>
<th>Separator</th>
<th>Formation Volume Factor $(v_{sat}/v)^1$</th>
<th>Total GOR (scf/stb) (m³/m³)</th>
<th>Stock Tank Oil (°API at 60 °F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Psig (KPa)</td>
<td>T °F (°R)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>200 (1379)</td>
<td>100 (560)</td>
<td>1.321</td>
<td>670 (119)</td>
</tr>
<tr>
<td>100 (690)</td>
<td>100 (560)</td>
<td>1.317</td>
<td>660 (117)</td>
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<tr>
<td>20 (138)</td>
<td>100 (560)</td>
<td>1.319</td>
<td>665 (118)</td>
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<td>0</td>
<td>100 (560)</td>
<td>1.320</td>
<td>667 (119)</td>
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1. The volume of reservoir oil at the saturation pressure and temperature relative to stock tank oil at 60 °F (520 °R)

Assume that the field is operated at optimum separator conditions.

Fluid and rock compressibilities are as follows:

$c_w = 3.5 \times 10^{-6} \text{ psi}^{-1}$ and 
$c_r = 11.6 \times 10^{-6} \text{ psi}^{-1}$.

Determine the amount of gas in solution, mmmscf, (m³) if the reservoir produces 1,200 mstb (190.8 mm³) of additional oil and is abandoned at 900 psia (6,206 KPa).

A. 287 (8.1)
B. 464 (13)
94. What is the breakthrough mobility ratio of an inverted 5-spot pattern undergoing waterflood with the average water saturation at breakthrough equal to 68% ($S_{wbt} = 0.68$)?

Use the following table of oil and water relative permeabilities to calculate your answer. Assume $\mu_o = 0.64$ cp and $\mu_w = 0.50$ cp.

<table>
<thead>
<tr>
<th>$S_w$</th>
<th>$k_{rw}$</th>
<th>$k_{ro}$</th>
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</thead>
<tbody>
<tr>
<td>0.050</td>
<td>0</td>
<td>1.000</td>
</tr>
<tr>
<td>0.199</td>
<td>0.047</td>
<td>0.630</td>
</tr>
<tr>
<td>0.252</td>
<td>0.064</td>
<td>0.526</td>
</tr>
<tr>
<td>0.296</td>
<td>0.081</td>
<td>0.454</td>
</tr>
<tr>
<td>0.368</td>
<td>0.110</td>
<td>0.341</td>
</tr>
<tr>
<td>0.396</td>
<td>0.123</td>
<td>0.297</td>
</tr>
<tr>
<td>0.449</td>
<td>0.155</td>
<td>0.229</td>
</tr>
<tr>
<td>0.502</td>
<td>0.182</td>
<td>0.157</td>
</tr>
<tr>
<td>0.549</td>
<td>0.218</td>
<td>0.108</td>
</tr>
<tr>
<td>0.593</td>
<td>0.248</td>
<td>0.065</td>
</tr>
<tr>
<td>0.633</td>
<td>0.279</td>
<td>0.032</td>
</tr>
<tr>
<td>0.667</td>
<td>0.311</td>
<td>0.014</td>
</tr>
<tr>
<td>0.693</td>
<td>0.343</td>
<td>0.004</td>
</tr>
<tr>
<td>0.705</td>
<td>0.356</td>
<td>0.001</td>
</tr>
<tr>
<td>0.715</td>
<td>0.361</td>
<td>0.000</td>
</tr>
</tbody>
</table>

A. 0.680  
B. 0.462  
C. 1.000  
D. 0.419
Using the fractional flow curve, what is the water saturation at the well at the time of breakthrough?

A. 0.68  
B. 0.64  
C. 0.72  
D. 0.05

96.
What is the original volume of gas cap gas in place in mscf (mm³) of a reservoir with the following parameters?

Area = 80 acres, (323,749 m²)  
net pay thickness = 50 ft, (15.2 m)  
average porosity = 20%,  
initial water saturation, $S_{wc} = 10\%$,  
initial gas saturation, $S_{g} = 10\%$,  
Initial Oil Formation Volume Factor, $B_{oi} = 1.42$ rb/stb, (1.42 m³/m³)  
Initial Gas Formation Volume Factor, $B_{gi} = 0.8$ rb/mscf (0.00449 m³/m³).

A. 7,757,800 (219,768)  
B. 6,982,020 (197,791)  
C. 775,800 (21,977)  
D. 620,624 (17,581)
97. A sonic logging tool recorded a travel time of 90 $\mu$s/ft in a loosely consolidated sand formation. From local experience it is known that sonic log travel times in this formation read too high because the formation is loosely consolidated. A correction factor, $C_p = 1.2$, should be applied to the Wyllie time-average equation to correct for lack of compaction. The matrix and formation fluid travel times are $\Delta t_{ma} = 51.0 \, \mu s/ft$ and $\Delta t_f = 189 \, \mu s/ft$.

What is the formation porosity, $\%$, predicted using the Wyllie equation with a compaction correction?

A. 17  
B. 24  
C. 28  
D. 34

98. From lab measurements on core samples from a zone of interest you are given the following Archie parameters: $F = 26.0$, and $n = 2.3$. From resistivity measurements on produced formation water samples, $R_w = 0.05 \, \text{ohm-m}$ at reservoir temperature. From log measurements, $R_t = 10.0 \, \text{ohm-m}$ and $\phi = 0.20$.

What is $S_w, \%$?

A. 33  
B. 35  
C. 36  
D. 41
A high-pressure gas reservoir had a discovery pressure of 10,000 psia \((6.895 \times 10^4 \text{ KPa})\). PVT analysis of the gas indicated the following variation in deviation factor, \(z\), with pressure.

\[
\begin{array}{cc}
p, \text{ psia} & z, \text{ dimensionless} \\
10,000 \ (6.895 \times 10^4 \text{ KPa}) & 1.47 \\
8,000 \ (5.516 \times 10^4 \text{ KPa}) & 1.30
\end{array}
\]

Formation water compressibility was \(3.5 \times 10^6 \text{ psia}^{-1} \ (5.076 \times 10^{-7} \text{ KPa}^{-1})\), initial water saturation 25\%, and constant formation compressibility \(2 \times 10^{-5} \text{ psia}^{-1} \ (2.901 \times 10^{-6} \text{ KPa}^{-1})\).

Estimate the percentage, \%, of original gas in place produced when reservoir pressure drops from discovery pressure to 8,000 psia \((5.576 \times 10^4 \text{ KPa})\).

A. 9.54  
B. 14.6  
C. 20.0  
D. 85.4

A gas reservoir has a reliable estimate of original gas in place of 400 Bcf \((400 \times 10^9 \text{ scf, } 1.133 \times 10^{10} \text{ std m}^3)\). There may be water influx into the reservoir from an aquifer. Estimate the cumulative water influx in reservoir barrels (RB) (or reservoir cubic meters, res m\(^3\)) if, after two years of production, average reservoir pressure has dropped from an original 5,000 psia to 4,000 psia \((3.44 \times 10^4 \text{ kPa to } 2.758 \times 10^4 \text{ kPa})\).

Other information is summarized below.

<table>
<thead>
<tr>
<th>Time, years</th>
<th>Average reservoir pressure, psia</th>
<th>RB/Mscf</th>
<th>(B_p) (\text{res m}^3/\text{m}^3)</th>
<th>(G_p) (\text{std m}^3)</th>
<th>STB</th>
<th>(W_p) (\text{std m}^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5,000</td>
<td>3.447 \times 10^4</td>
<td>1.0</td>
<td>5.615 \times 10^{-3}</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>4,000</td>
<td>2.758 \times 10^3</td>
<td>1.2</td>
<td>6.737 \times 10^{-3}</td>
<td>66.7</td>
<td>1.889 \times 10^6</td>
</tr>
</tbody>
</table>

Assume water formation volume factor is 1.0 RB/STB \((1.0 \text{ res m}^3/\text{m}^3)\).

A. \(66.74 \times 10^6 \text{ RB} \ (10.61 \times 10^6 \text{ res m}^3)\)  
B. \(4 \times 10^4 \text{ RB} \ (6.36 \times 10^3 \text{ res m}^3)\)  
C. \(66.7 \times 10^6 \text{ RB} \ (10.6 \times 10^6 \text{ res m}^3)\)  
D. \(80 \times 10^3 \text{ RB} \ (12.72 \times 10^3 \text{ res m}^3)\)
Answer Key:
1. A
2. D
3. C
4. A
5. D
6. D
7. B
8. D
9. C
10. A
11. C
12. B
13. C
14. B
15. B
16. C
17. A
18. C
19. B
20. B
21. D
22. A
23. D
24. C
25. B
26. A
27. D
28. A
29. D
30. B
31. C
32. D
33. A
34. C
35. C
36. C
37. B
38. C
39. A
40. C
41. B
42. B
43. C
44. D
45. D
46. A
47. A
48. C
49. B
50. B
51. D
52. A
53. B
54. D
55. A
56. B
57. A
58. B
59. C
60. A
61. D
62. C
63. D
64. B
65. A
66. D
67. D
68. C
69. A
70. D
71. B
72. A
73. B
74. C
75. D
76. A
77. A
78. B
79. C
80. C
81. A
82. D
83. C
84. D
85. C
86. B
87. C
88. B
89. A
90. B
91. C
92. C
93. A
94. D
95. B
96. C
97. B
98. D
99. B
100. D