CAPILLARY PRESSURE EXERCISE

This exercises uses data from the Elysian Field.

Well: 24-1X
Depth: 3100 m
Lithology: Slightly shaly sandstone (90%sandstone, 10% shale)

A mercury injection capillary pressure experiment has been carried out on a core plug from well 24-1X of the Elysian Field at a depth of 3100 m.

The following data were collected:

Cap. Press. (Hg-Air) @25°C (psi)	**S_{Hg}**	**S_{Air}**	**S_w**	**S_o**	**Cap. Press. (Oil-Water) @ 25°C (psi)**	**Cap. Press. (Oil-Water) @ Reservoir Temp. (psi)**	**Height above FWL (m)**	**Change in Hg Satura-tion**	**Pore Throat Radius (mm)**
1.00	0	1					0.16		106.72
2.00	0	1							
4.00	0	1							
7.00	0	1							
9.00	0.05	0.95							
9.03	0.12	0.88							
11.70	0.25	0.75							
17.00	0.38	0.62							
24.00	0.46	0.54							
37.50	0.50	0.50							
57.89	0.55	0.45							
84.50	0.61	0.39							
114.00	0.70	0.30							
154.00	0.77	0.23							
200.00	0.81	0.19							
270.00	0.85	0.15							

Fluid System	**Interfacial Tension (dynes/cm)**	**Wetting Angle (degrees)**
Mercury-Air	368	0
Oil-Water @ 25°C	35	0
Oil-Water @ Reservoir Conditions	28	20

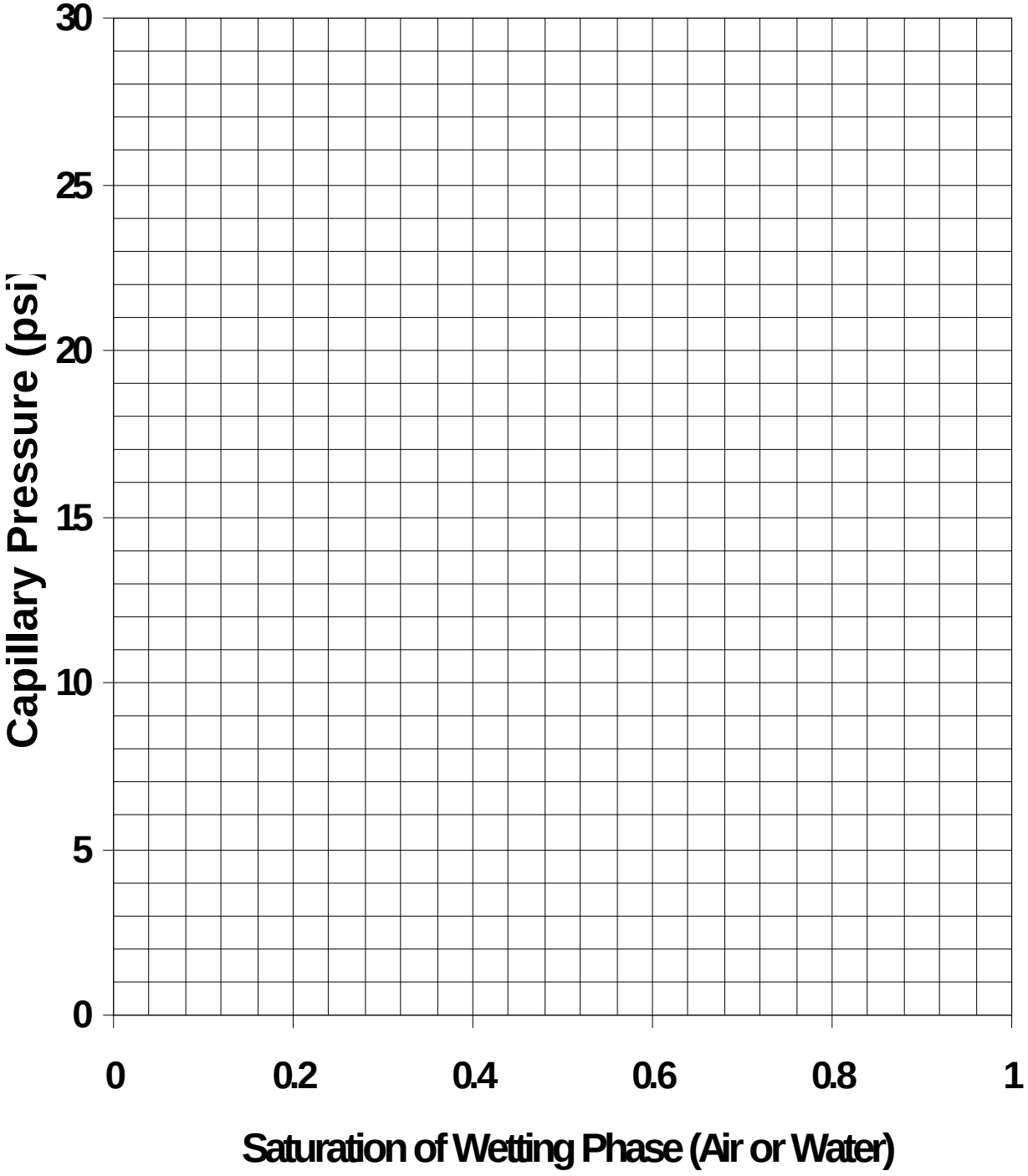
In the following calculations use values for interfacial tension and wetting angles given in the table above.

(a) Convert the mercury-air capillary pressure to oil-water capillary pressure at 25°C and fill in the table.

(b) Fill in the appropriate values for water saturation and oil saturation that apply to the data calculated in (a).

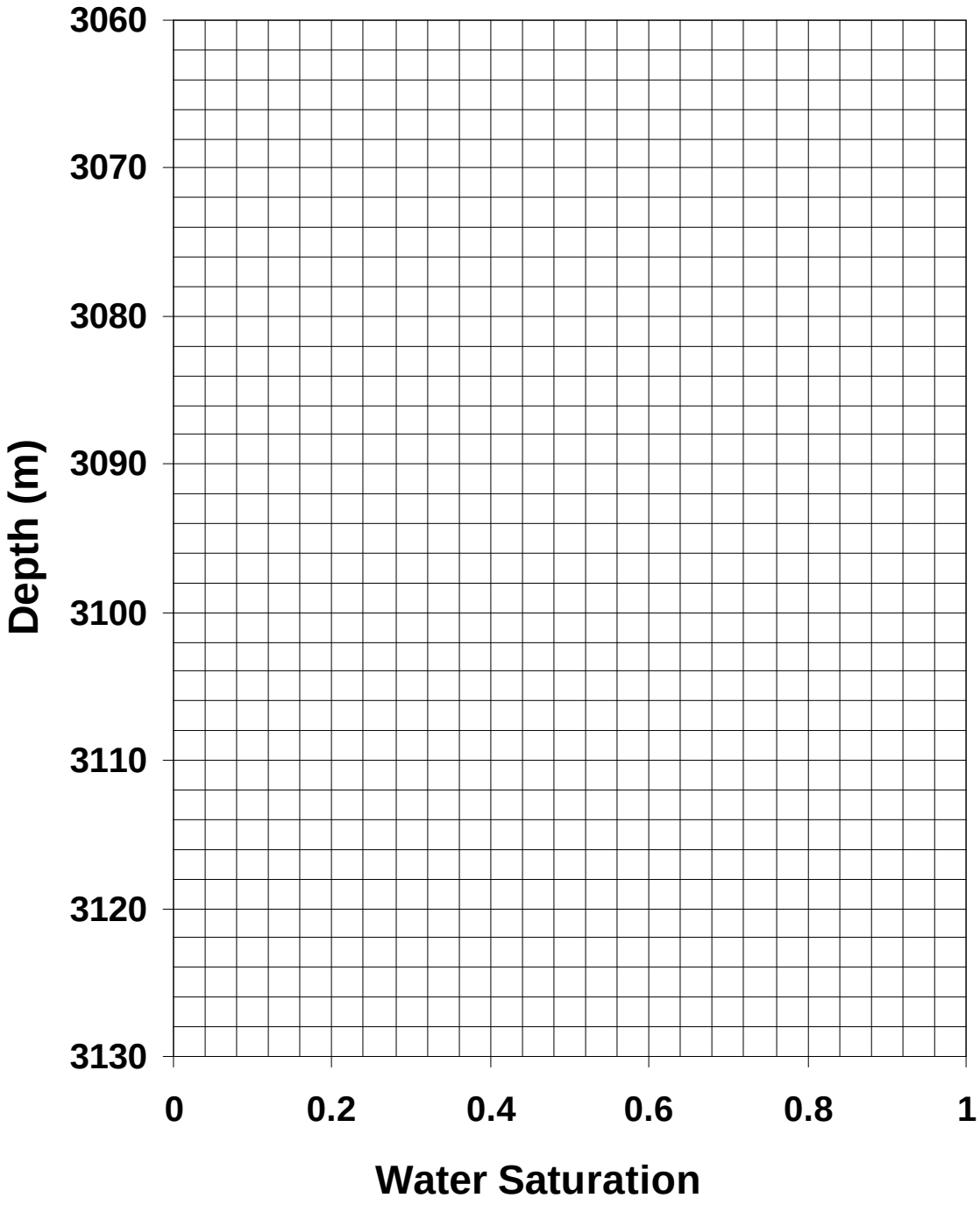
(c) Convert the oil-water capillary pressure at 25°C to oil-water capillary pressure at reservoir conditions and fill in the table.

(d) Draw a graph of the capillary pressures for both the oil-water at 25°C and the oil-water capillary pressure at reservoir conditions (y-axis, linear 0 to 30 psi) against the saturation of the wetting phase (air or water) (x-axis, linear 0 to 1.00).



(e) Given that the reservoir interval contains both water and oil, and that the fluid pressure gradient in the oil leg is 1.015 psi/m, and in the water leg is 1.45 psi/m, calculate the height above the free water level for each value of capillary pressure, and insert the data into the table.

(f) Given that the free water level exists at 3120 m, draw a graph of water saturation (x-axis, linear 0.0 to 1.0) against depth (y-axis, linear 3060 m at top to 3130 m at bottom).



(g) Mark the free water level on the graph.

(h) At what depth is the oil-water contact (*OWC*), and mark it on the graph?

(i) What are the water and oil saturations at the following depths: 3125 m, 3119 m, 3110 m, 3090 m?

(j) What, approximately, is the value of the irreducible water saturation?

(k) If the rock sample had a greater percentage of shale, would you expect a higher or a lower value of S_{wi}, and why? Draw on the graph created in part (f) an example of the curve that would be produced if the lithology was a sandy shale (say, 40% sandstone, 60% shale).

(l) Equation (4.4) in the notes relates capillary pressure to interfacial tension, wetting angle and the radius of the aperture in which the fluid interface exists. This equation is for capillary pressure in dynes/cm^2, interfacial tension in dynes/cm, wetting angle in degrees, and radius in cm. If you multiply the right hand side of the equation by 0.145, the equation is valid for capillary pressure in psi, interfacial tension in dynes/cm, wetting angle in degrees, and radius in microns.

Rearrange this modified equation to calculate the radius of the aperture (in microns) from the mercury-air capillary pressure (in psi).

Calculate the aperture values for each value of mercury-air capillary pressure, and insert the results into the table. Note that these apertures represent the radii of pore throats in the rock.

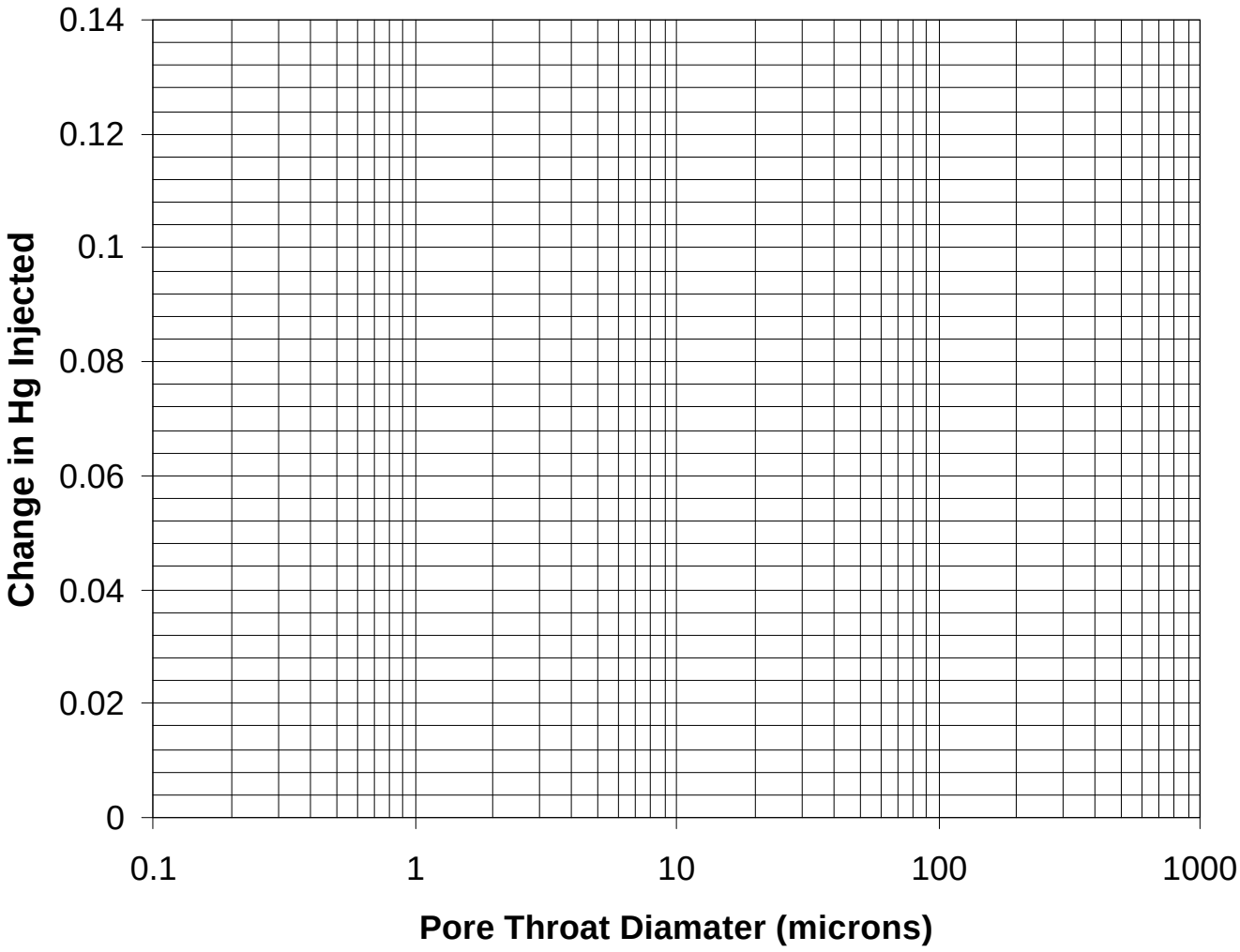
(m) Calculate the incremental increase in mercury saturation for each row of the table, and insert the results into the table.

(n) Draw a graph of incremental increase in mercury saturation (y-axis, linear 0.0 to 0.14) against the calculated radius (x-axis, logarithmic 1000 to 0. 1).

(o) Write a brief paragraph interpreting the physical meaning of this graph.

(p) Given that the graph calculated in (n) is for the rock sample at 3100 m, which is a sandstone with a small amount of shale (say 90% sandstone, 10% shale), draw freehand on the graph constructed in (m) the likely curve for a sandy shale (say 40% sandstone, 60% shale).

(q) Justify your choice of curve in (o).


0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Change in Hg Injected
0.1
1
10
100
1000
Pore Throat Diamater (microns)