3. [10 points] The San-Ti, inhabitants of a nearby star system, are terraforming an uninhabited planet which they are hoping to relocate to in the future. The planet is venting oxygen and does not yet have enough of it for them to survive, so they have placed large oxygen generators along with some vegetation on the planet's surface to increase the amount of oxygen in the atmosphere.

Let $A(t)$ be the rate at which oxygen is being added to the planet's atmosphere, and $S(t)$ the rate at which oxygen from the atmosphere is leaking into space, both measured in petagrams (Pg) per decade, t decades after the terraforming began. Graphs of $A(t)$ and $S(t)$ are shown below.
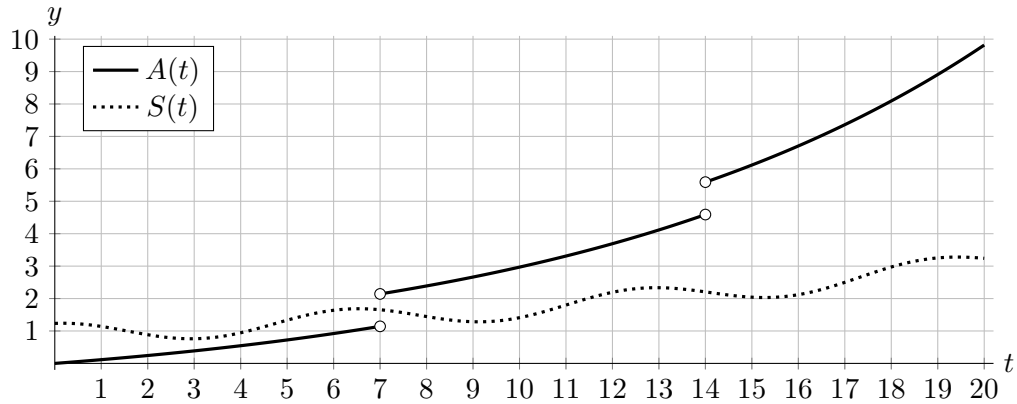
a. [2 points] Estimate the rate, in petagrams per decade, at which the amount of oxygen in the planet's atmosphere was changing 15 decades after the terraforming began.

Answer: _____4_____ petagrams per decade.

b. [2 points] Write an expression for the total amount of oxygen, in petagrams, that leaked into space from the planet's atmosphere over the first 10 decades since the terraforming began. Your expression may involve one or more integrals.

Answer: $$\int_0^{10} S(t)\, dt$$ petagrams.

c. [2 points] Estimate the number of decades after terraforming began when there was the *least* amount of oxygen present in the planet's atmosphere.

Answer: _____7_____ decades.

d. [2 points] Write an expression for the average rate of change in the amount of oxygen in the planet's atmosphere over the first 20 decades of the terraforming operation, in petagrams per decade. Your expression may involve one or more integrals.

Answer: $$\frac{1}{20} \int_0^{20} \big(A(t) - S(t)\big)\, dt$$ petagrams per decade.

e. [2 points] The San-Ti want to start the first colony on the planet as soon as there are at least 150 Pg of oxygen in the planet's atmosphere, but not before. Assuming there were 100 Pg of oxygen in the planet's atmosphere when the terraforming began, about how many decades must they wait before setting up their first colony? Choose the one <u>best</u> answer below.

| 7 | 12 | 14 | 17 | 20 | MORE THAN 20 |