Q1 $N_3 + N_4 \leq (N_2 + N_4) + (N_3 + N_7)$
$-N_3 + N_4 \qquad\qquad -N_3 + N_4$

$$0 \leq N_2 + N_7$$

Since a population number of particles can't be negative, it's true.

Q2 Populations 3 + 4 are the only ones with +a for particle 1 and +b for particle 2. Since these are the only way to get this outcome, this sum over the total of all populations is the probability

Q3 $3 \to 2$ $4 \to 4$ $+a \to +a$ $+b \to +c$ in the argument above.
analogous mapping for S, S3

Q4 $P(+a, -b) = \dfrac{N_1 + N_2}{\Sigma_i N_i}$ since populations 1 + 2 are the only ones that generate this outcome

Q5 +a is the eigenvalue of spin along the a direction
+b eigenvalue of spin along the b direction
The first 0 is total spin, $\hat{S}^2$
The second is total "z" component $\hat{S}_{1a} + \hat{S}_{2a}$ or total "a" component or whatever axis, they are all 0.

A2

Q6 1) $|-a,+a\rangle$ this is the $\hat{S}_{1a}$ $\hat{S}_{2a}$ representation of $|0,0\rangle$

2) I can represent these 2-particle states as products of single-particle states. The part where ${}_1\langle +a|$ hits $|-a\rangle_1$ is zero, the last part of the surviving term is

$$|-a\rangle_2$$

3) Just a little more algebra. the blank is still

$$|-a\rangle_2$$

Q7 $P(+a;+b) = \frac{1}{2}|\langle +b|-a\rangle|^2$

$$= \frac{1}{2}\left|\left(\langle +a|\cos\frac{\theta_{ab}}{2} + e^{i\phi}\sin\frac{\theta_{ab}}{2}\langle -a|\right)|-a\rangle\right|^2$$

$$= \frac{1}{2}\sin^2\frac{\theta_{ab}}{2}$$

Q8 $P(+a,+c) = \frac{1}{2}\sin^2\frac{\theta_{ac}}{2}$

$P(+c,+b) = \frac{1}{2}\sin^2\frac{\theta_{cb}}{2}$

Q9 $\frac{1}{2}\sin^2\frac{\theta_{ab}}{2} \leq \frac{1}{2}\sin^2\frac{\theta_{ac}}{2} + \frac{1}{2}\sin^2\frac{\theta_{cb}}{2}$

$\theta_{ab} \downarrow 50°$ $\theta_{ac} \downarrow 25°$ $\theta_{cb} \downarrow 25°$

$0.29 \leq 0.17$